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ASTRONOMY.

OCCULTATION OF VENUS, DECEMBER 8, 1877.

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This phenomenon was witnessed over all the Western States, particularly north of the parallel of 38°. To the astronomer it is gratifying to know how *very general* was the interest taken in its occurrence. This interest was not confined to the educated, but was shared by the most unlettered and even by young children. Hesperus, the glorious Evening Star, which in Eden

"* * * * Led the starry hosts, and brightest rode,"

has in all ages been an object to compel the attention and admiration of beholders. But to find it on a clear, calm evening, first in close proximity to the Moon, and next suddenly obscured by it, as if blotted out of Heaven, surprises those unaccustomed to such events, and powerfully awakens popular interest in celestial phenomena. Yet this event is only *one* of a class. Kindred phenomena occur almost daily. Though unseen in America, Venus herself is occulted twice during the year 1878—January 6th and August 25. Also during the year the planet Jupiter will be occulted ten times, Mars twice, and Uranus three times. The Solar Eclipses, of which

two occur in 1878, are but occultations of the Sun. The occultation of the planet Saturn in August and September, 1876, was a rare astronomical event. The immersion and emersion of the edge of the ball, and of the ansæ of its ring, and the appearance of the Moon's limb in the void space between the ring and the great ball, were observed with marked interest by astronomers. The reader may find an account of the Washington observations of this occultation as observed by Prof. Hall and others, in the "Astronomische Nachrichten," No. 2107. He may also find accounts of the occultation of Jupiter, January 2, 1857, in Month. Not. R. A. S., Vol. XVIII; also of the occultation of Saturn, May 8th, 1859, Month. Not. R. A. S., Vol. XIX. The occultation of the beautiful planet Uranus, was very carefully observed at the Morrison Observatory, Glasgow, Mo., April 21, 1877.

Moment of first contact or beginning of partial phase, 13*h*. 28*m*. 43.5*s*. Gl. Sid. Time.
Moment of internal contact or beginning of total phase, 13*h*. 28*m*. 47.5*s*. Gl. Sid. Time.

The external contact of emersion occurred at 14*h*. 18*m*. 50.5*s*., hence the planet was *entirely concealed* by the Moon, 50*m*. 3.5*s*. The occultation of one planet by another planet than the Moon, is of *exceedingly* rare occurrence. Such was the occultation of Mercury by Venus, May 17th, 1737. The occultation of a *first* magnitude star is an astronomical event nearly as interesting as that of Venus. Four such stars lie near the Moon's path, and are liable to occultation. They are Aldebaran, Regulus, Spica and Antares. The accurate observation of the immersion and emersion of *all* well determined stars, furnishes to the astronomer the best purely *theoretical* method of computing differences of longitude. In such observations the notation of the precise instant of appearance or re-appearance, is of the utmost importance. This notation is made by the Electro-Magnetic Chronograph, and is instantaneous. The clock or chronometer error is ascertained in the same way from meridian transits of stars. Aside from the error of personal equation, the clock correction may thus be obtained to the $\frac{1}{100}$ part of a second.

With these preliminaries, I return to the occultation of Venus. The evening at this Observatory was as favorable as possible. The sky was cloudless, and temperature agreeable, being 37 Fahr. in the open air. Many persons noted by watch the moment of disappearance. This was the only phase *distinctly* cognizable by the unassisted eye. But in a large telescope there were present several phases of very great interest. I will try to describe them, not for anstronomers, but for the young and the plain, practical people, who have shown so much interest in the event. I shall speak of the phenomena as they appeared in the field of a large refracting telescope, under an amplifying power of 250. In such a field all the images are *inverted*—up and down—right and left—east and west—north and south, all exchange places. The diagrams, I send with this text, are intended to show the phases, as seen in the field of the telescope. Again, since in a large instrument, with even a moderately high eye-piece, only a very *small* portion of the Moon's surface can be seen, while the whole *visible* surface of

Venus occupies a conspicuous part of the field, there is no way to secure the *just optical effect*, but by drawing Venus with an *apparent diameter* far greater than is due. Strictly, the lunar diameter should appear 73 times greater than that of Venus. Hence, if the apparent diameter of Venus be taken $\frac{1}{10}$ inch, the apparent diameter of the Moon *should be* 7.3 inches. Even the scale I have adopted in the diagrams scarcely gives the full optical effect, since the perfect semi-circle of Venus, with its dazzling brightness, was full advanced in the field, while only a small segment of the Moon could be admitted.

The *unassisted* eye could readily see, beside the bright crescent of the Moon, the dark portion of her disc, rendered visible by the reflection of light from the Earth. This feebly lighted surface, exhibiting what is called the "ashy light," (*la lumière cendré*) exists in Venus just as in the Moon, only it is barely distinguishable on very clear evenings, in powerful telescopes. On the evening of December 8, Venus was only three days from her greatest eastern elongation, and hence her disc was almost perfectly divided into semi-circles—one brilliantly lighted by the Sun's direct rays, the other entirely dark—even the "ashy light" fading out in presence of the Moon. For half an hour, to the unassisted eye, Venus seemed to stand still on the northeastern limb of the Moon, on the very border of "ashy light." Some grew weary of watching it, and thus missed the moment of immersion. At 5:20, Glasgow mean time, the images of the Moon's dark limb and of Venus were brought into the field of our Clark Refractor—the bright semi-circle of Venus being turned towards the Moon's dark limb. The limbs were then separated by an interval of three or four minutes of arc. The purity of the air showed the Moon's dark limb to great advantage—the sky beyond appearing intensely black in contrast with the "ashy light." The border was most distinctly marked, and I patiently watched the gradual approach of the bright and ashy discs, with finger on the break-circuit key, so as to note on the Chromograph the moment of contact. The view was rare and beautiful. Even the brightest fixed star exhibits no *real* disc; but here two great spheres, projected as circles, were rapidly approaching each other.

When the bright limb of Venus was within eight or ten seconds of the Moon's "ashy limb," a phenomenon occurred which has always been noted in a *superior* degree in the transits of Venus across the Sun's disc. It may afford some indication of the *extent* and *density* of the atmosphere of Venus. Instead of a *sharp, closely defined* contact of discs, which was so fully promised, a border of wavering light, several seconds in width, seemed to precede the planet. This irradiation was such as to place the moment of external contact in doubt, by perhaps *one* second. The instant noted was $22h.\ 48m.\ 15.52s.$ Gl. Sid. time—corresponding to $5h.\ 36m.\ 55.94s.$ Gl. mean time. This time must be taken rather as the instant of first *appreciable encroachment* on the bright limb of the planet. The effect of this bright arc of light was such, in transit observations of the British expeditions of 1874,

as to place the moment of *internal* contact in doubt by five or six seconds, and to cause the *rejection* of all observations of this phase in computing the Solar Parallax. From this occultation of Venus, I feel sure that no part of *that effect* can be due to the Solar Corona; but must be ascribed either to irradiation and diffraction or to the disturbing effect of the atmosphere of Venus. The phase of external contact, which could not be observed by the unaided eye, is illustrated in Diagram No. 1. It marks the *beginning* of partial phase at immersion. The curve of the Moon's dark limb, projected on the bright semi-circle of Venus, now rapidly advanced towards the straight line or diameter, dividing the enlightened and unenlightened halves. This line is called the Terminator, and is marked by the letters *n*, *s*, in all the figures. In 31.11*s*. (seconds), the curve reached the northern point or cusp of the planet, as shown in Diagram No. 2. This cusp was simply *blunted*, but there was no disturbing arc of light, and the time was instantaneously noted, at 22*h*. 48*m*. 46.63*s*. Gl. Sid. time, or 5*h*. 37*m*. 28.2*s*. Gl. mean time. Now began the most *interesting* part of the phenomena. As the arc advanced, the curve cut off more and more of the sector-like surface yet illuminated. But 18.99*s*. now remained, and in that brief space there was much to see. They were moments of intense excitement, as I watched that triangular surface of light, bounded by two curves and a straight line, gradually fading into nothingness.

Fig 1

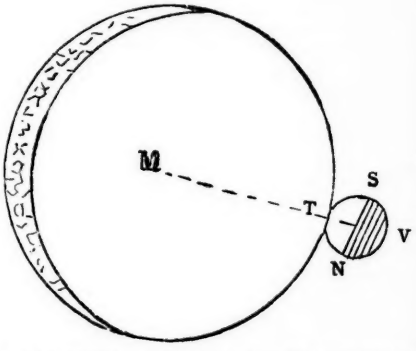
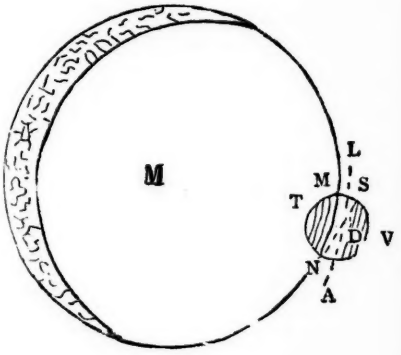


Fig 2



In figure 2, I have drawn the arc *l a*, to mark the position of the Moon's limb and the rapidly vanishing surface of light, but six or eight seconds before the beginning of total phase. In a few seconds more the southern cusp shot out its *last ray* and Cynthia had vanquished Venus. See Diagram No. 3. This instant was noted at 22*h*. 49*m*. 5.6*s*. Gl. Sid. time, corresponding to 5*h*. 37*m*. 47.14*s*. Gl. mean time. At this time however, all the dark lune of Venus, bounded by the curves *m s* and *m c s*, was still projected beyond the Moon's "ashy limb."

In the emersion, first came the internal contact of discs. See Diagram No. 4. This marks the close of the total phase. Occurring on the Moon's

Fig 3

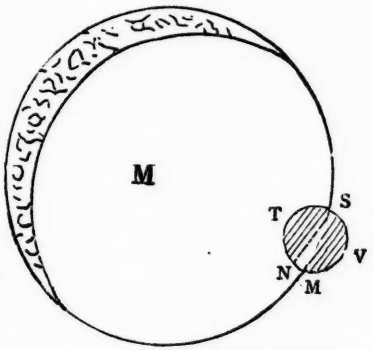
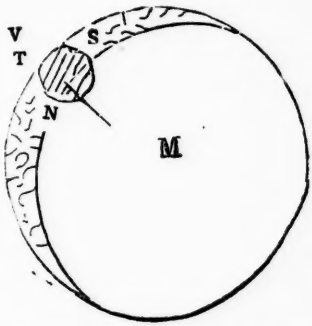


Fig 4



bright limb, the time of its occurrence, or rather the instant of *first light* from the rim of Venus, could not be so distinctly noted as the moment of the preceding phases. I therefore used the time to change the position of the dome and shutters, and noted neither the time of internal contact nor the *emersion* of southern cusp. See Diagram No. 5. The emersion of the

Fig 5

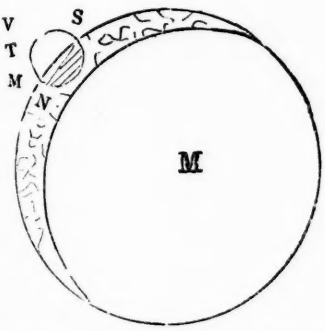
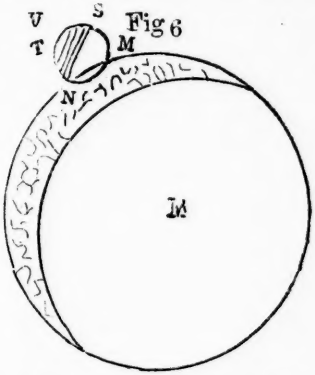


Fig 6



northern cusp is shown in Diagram No. 6. It was observed at 23*h*. 58*m*. 15.27*s*. Gl. Sid. time, or at 6*h*. 46*m*. 44.16*s*. Gl. mean time; the duration of the phenomenon, from first contact to the emersion of the northern cusp being 1*h*. 9*m*. 59.75*s*. The clock error of the night of December 8, was most carefully ascertained by meridian transits of seven standard stars—the observations being reduced by the method of least squares. Hence, any person so disposed, may confidently use phases two and three for computing differences of longitude from Washington or Greenwich. For any such I will add that the latitude of the dome of the Observatory has been rigorously determined, and found to be 39° 16′ 16.75″ + 0.05″.

MORRISON OBSERVATORY, January 24, 1878.

METEOROLOGY.

ABOUT THE ATMOSPHERE AND ITS PHENOMENA.

BY HON. R. T. VAN HORN, KANSAS CITY, MO.

This globe on which we are is the great mystery. Science tells us that it is suspended in space—moving with a velocity that the imagination cannot grasp. it keeps its ceaseless round—bringing its day and its night and its alternating seasons, since the morning of matter; an incomprehensible mystery that has been the wonder of our humanity, into whose secrets the intellect of man has delved in all the ages as containing the answer to the question of how and why he exists?

With this solid globe, ever present, all pervading, obeying the same law as to fixedness and movement, is a fluid ocean, impalpable to sense, that we call the air or atmosphere—a mystery more subtle, more incomprehensible than even the seemingly solid mass of matter it envelopes. In it all the phenomena of life are manifested, and from it all life exists or is possible. It is the theatre, so to speak, on which transpire those displays of the elements which charm by their beauty, confound by their mystery or awe by their majesty and power. The zephyr and the storm are equally its children; the glories of sunset entrance us by their coloring, while the glow of the aurora appeals to the weird sense of the supernatural by the rapid shifting of its mysterious scenery. It spreads above us its canopy of blue, fit field for the god of day; at night it wraps the Earth in a robe resplendant with shining jewels. It is, too, the same air when the curtain of the storm hides this glory of the day or beauty of the night, proclaiming its angry power by its lightnings and thunder.

It comes also to reviving nature in the gentle breath of the warming south wind, kissing the flowers as they bend their congratulations to its coming; and on its wings comes the north wind, congealing life in the elements for their winter's rest—the one messenger of life and of death. By it the bracing breezes of health are scattered over the earth, and in its train pestilence stalks from continent to continent, the terror-invested mystery that chills the nations with dread. What is this wonderful thing?—so common, yet so little known—and whence was it, or from whence is it?

Science tells us it is a material thing—that it is composed of elements that can be weighed and measured, and that it has all the qualities of matter—can be compressed or expanded. In short, speaking chemically, it is composed of nitrogen, oxygen, carbonic acid, ammonia, ozone and vapor of water—mainly of the first two, in the proportions of four volumes of nitrogen to one of oxygen. Its weight we may place in round figures at fifteen pounds to the square inch. Its height, judging from the barometer

at the highest elevations attained for observation, would be about thirty miles. Its theoretical height—that is the point at which gravity would cease to control it with the Earth's rotation—is twenty-one thousand miles. That it does not extend thus far optical experiment demonstrates.

These formula as to the air are from the latest and best authorities. And here it may be proper to state, that when any data are used, they are taken from accredited authority—they are not mine—they may be taken as facts; only the conclusions, good or bad, may be laid to this paper, and are alone chargeable to it. This statement is necessary because it is impossible in an hour to give references, to say nothing of quotations. It is only from these facts coming under notice in the desultory reading of a journalist, that I have ventured to ask a few questions as to the nature of these facts, or the origin of the element to which they belong.

The above is the chemical composition of the air—or rather what chemical experiment has determined as the elements composing the atmosphere.

We must not make the common mistake, and designate the air as a combination of these elements in a chemical sense—for it is not. It is simply a mixture of these gases. A chemical combination of two or more substances always produces a new one—or a substance differing in quality from any of its components. Water is oxygen and hydrogen combined—a chemical combination—air is simply a mixture. And in determining the offices of the atmosphere, and investigating its phenomena this fact is of fundamental importance.

And now, before inquiring into the nature of the atmosphere, let us first examine the commonly accepted theory of the phenomena witnessed, and its primary movements that we call the wind. For if this theory accounts for these phenomena satisfactorily, mere conjecture as to something else is not only waste of time, but without apology. And this commonly accepted theory is nearly two hundred years old—and has been endorsed by what the scientific world recognizes as regular authority.

The popular idea is that the atmosphere is a distinct element, or creation, enveloping the earth—constant and unchangeable—and which is of itself inert and without individuality, so to speak—a plastic element, moving as impressed by external agency—and that agency heat from the Sun.

The most noticeable of atmspoheric phenomena are the winds. Halley, in 1686, as a mere hypothesis, proposed what has ever since been accepted as a fact or law—that the movement of the air—or winds—was due to the Sun's heat, and that all the varied manifestations, from the zephyr to the hurricane, were the results of this agency in modified or intense activity.

The most constant and noticeable of all these movements are the trade winds, which blow from both sides of the equator toward it. This fact was the origin of the theory, but the cause of the fact, as given in the theory, does not accord with observations since. The theory of Halley was briefly this:

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(1) That at the equator or within the tropics, where the rays of the Sun are vertical, and constant in intensity, the surface air becomes heated, and expanding, rises, creating a vacuum, and as this is an abhorrent thing to nature, the air from the cooler surfaces rushes in to fill it—or as the latest cyclopedia has it: "to fill the spaces left by the airs that have become heated and passed up to the more elevated portions of the atmosphere in the belt of the equatorial calms."

(2) That this heated air, rising to a supposed height in an immense column of several hundred miles diameter, divides in the upper regions and flows off to the respective poles, supplying in its turn the place of the cooler air drawn inward to the centre—making a circulation by two complete circular currents coincident with the hemispheres of the globe. Here, then are two vacuums, in permanent existence, or rather a continuous vacuum of which the wind is in constant pursuit. If this is the law of atmospheric movement, it must be consistent in all its parts—the lesser motion as well as the grand movement of the whole.

Now, what do we know? Take, almost any day in the year, a weather chart of the signal office, on which is marked the direction of the wind at a given hour all over the American continent, and what do we find?—the wind as varying in its direction as the points of the compass. At Kansas City a north wind, at Omaha a south wind, at Denver an east wind, and at St. Louis a west wind. At Fort Scott, southwest, at Laramie northwest, at Chicago northeast, and New Orleans southeast. As changeable as the wind, is a proverb as old as human observation.

Then again, as we all know, here and all over Southern Kansas, we may be to-day basking in the mildest weather that a southern breeze can bring us, or we may be sweltering with the torrid heat of summer, while at the very same hour a fierce and chilling norther may be sweeping down the plains of Texas. Or, we may ourselves be chilled with the raw breath of an east wind, while above our heads in plain view from the west, is a warm river of air flowing onward, bearing in its current the warm rain, and flashing with the lightnings evolved from its latent heat. These things we see and know, they are not consistent with such a law as we have been considering. These facts have led to the question—is this theory, old as it is, supported by so much authority as it is, true? Is this theory based upon the general law as to expansion by heat, and illustrated by the trade winds, the fact? It is proposed now to test it by the record of the thermometer, kept for a long series of years, both in the latitudes where this heating process is supposed to be going on, and where the vacuum is created, as also in the latitudes where the cooler portions are assumed to be, from which the refrigerated winds flow to the thermal vacuum, and over which they blow. And we shall not only show that this assumption is not warranted by the facts, but that these trade winds actually do blow from surfaces more highly heated than those into which they blow—and that their movement is from a higher into a lower temperature. The tables used are mainly those of

Kaemtz, Dr. Barth, Prof. Coffin, and others—covering long series of years, and at all seasons.

Commencing on the west coast of Hindostan, we have a table by Kaemtz in his treatise on meteorology, kept at Anjarakandy, a place where the trades "shorten up," as the theory tells us. When the trades blow over this place, between 12° and 13° north latitude, the thermometer stands during April at a mean of 85° Fahrenheit—and when the Sun is south. In July, when the Sun is vertical, and the "belt of calms" is over it, the thermometer is 77°. And after, in November, when the trades sweep over it again, and the Sun is south, it is at 80°—a difference of 5° and 8° against the theory.

Next we come to Northern Africa, and with the record of Dr. Barth, at Kukuwa and Soudan—latitude 12° north, when the trades blow the mercury for more than half the days, is above 100°, in April, May and early June, while the Sun is not vertical. In August, when the trade is "shortened up," and does not blow, and when the Sun is vertical, the thermometer only rose above 90° on two days. And after, in October, when the trades returned, and the Sun was not vertical, it rose again to above 100° on every day of the month save two.

According to Dr. Barth, between May and October, when the Sun was not vertical, and July and August when it was vertical, the mean difference in the thermometer was 15° against the theory.

We now come to the North Atlantic, where we have the tables of no less authority than those of Dove. On latitude 14°, the limit of the trades, the temperature for five degrees north of this is always at least two degrees higher. And here the tables of Prof. Coffin, published by the Smithsonian Institute, are also available. These show that for six hundred miles of the African coast, adjoining the great Sahara desert, on which the surface is heated to a daily temperature of 130° to 160°, and where the thermometer stands in the shade during the summer months, as high as 112°, the wind draws off from this heated surface and blows into a region where the mercury is never over 84°—and according to Prof. Coffin's map of the trades, when by the theory the wind should blow from the sea into this heated area, constantly, that in only twelve recorded instances out of three hundred and ninety-four, in the month of August, did the wind blow from any quarter to this hot region or toward the shore anywhere. The hot desert does not draw the winds from the cool ocean, nor does it in the least hold back or disturb the trades which blow over it—but they blow uninterruptedly from land heated to 130° every day on to water which is never heated over 82°.

The next to consider is South America, north of the equator, on the plains of the Orinoco, where we have the testimony of Humboldt, when the trades are blowing over them. These are his words: "When beneath the vertical rays of the bright and cloudless sun of the tropics, the parched sward, crumbles into dust, then the indurated soil cracks and bursts, as if rent asunder

by some mighty earthquake. The hot dusty earth forms a cloudy veil, which shrouds the heavens from view, and increase the stifling oppression of the atmosphere, while the east wind (the trades) when it blows over the long heated soil, instead of cooling adds to the burning glow." And all this time to the south of this, this hot wind is blowing into an area far cooler, and where refreshing rains are present.

We have the same evidence from Lieut. Herndon, in his exploration of the Amazon, we find the same facts in the wind charts of Lieut. Maury, and Livingstone bears testimony to the same circumstance south of the equator in southern Africa.

Now, as to collateral or minor testimony—in the land and sea breezes, about which the same popular opinion prevails—that as the land cools at night there is a breeze seaward, because it retains a more equable temperature—but as the sun rises and heats the land the cool breezes come in from the sea. In some places, as on our own Atlantic coast, the winds do blow so, but on other shores they do not—and this difference shows that it is not this assumed law that governs—for a law does not hold good in one or two instances and fail in a half dozen. This is reversing the test that the exception proves the rule, by making it a rule entirely of exceptions. On the coast of north Africa it is not so. In southern Arabia it is not so. It is not so in eastern Africa along the Mozambique coast, from 10° to 20° south latitude, where is some of the hottest land on the globe. The cool breezes of the Indian Ocean do not there blow toward the land, but on the contrary from the furnace hot land into the cool ocean. And it is not so in that part of Hindostan which includes the region between the valley of the Oxus in Persia and the Aral Lake, although the land is heated from 103° to 150° and the atmosphere to 100°: on the contrary the wind blows steadily toward the cool sea—and blows from the north at that. And from Madeira by the Canary Islands, along the coast to Cape Blanco and the Cape de Verd Islands, either calms or dry winds from the desert are generally met with —the harmattan, or land wind of the desert, which is noted for taking the fine dust far out to sea.

All these are facts—of record by the thermometer, and by writers of recognized authority in science. These data alone would swell this paper beyond its limits, and they can only be summarized. But here they are for all the continents.

It is not the present purpose to notice the theory for these phenomena —that belongs to another view of the subject—but they are used to show that the commonly accepted theory of the causes which create the winds and the movements of the atmosphere—the heat derived from the sun by a great uprising vortex at the equator, which causes the cool air to rush in from the poles to restore the equilibrium—does not explain them—because the facts are opposed to it.

We must then revise our ideas of the atmosphere itself. It cannot be the dead fluid, without property or force within itself, that we have been

led to think, and only acted on by forces from without. It must have inherent or latent forces within itself joined with the solid earth by influences acting and re-acting, and constant, to satisfactorily account for all these phenomena. The earth and the atmosphere are no more separate entities than are the solid earth and the fluid water. They are to be viewed as blended in their relations, because all are of a common origin—obeying a common law, controlled and perpetuated by kindred forces—all but the same matter in varying forms.

As facts contradict the theory upon which phenomena of the atmosphere have been accounted for in the past, we must seek hypotheses in harmony with the facts. As experiments have always proceeded upon the old theory, they have been accredited when reconcilable with it, and when not have been set aside as not understood, rather than as needing inquiry because they differed with or could not be combined with the theory.

As an illustration of this it is only necessary to refer to nitrogen, which is disposed of by the simple declaration—"its office is unknown"—when it comprises 76.7 per cent. of the entire volume of air. Our entire knowledge, save here and there a shadow, of life and its manifestations is confined to the part played by oxygen, which is but 23.2 per cent. Can we call it science when this is the extent of our knowledge? Does not reason tell us that life, existing in a fluid ocean, finding no office essential to its development, growth and sustenance from three-fourths of the volume of the element it inhabits—is an unsatisfactory solution?

How came the atmosphere? ought to be our first inquiry. And how is it maintained to perform its uses? should be the next.

The solar sytem is a fact. It obeys the same laws; it is controlled by the same forces; they are the same in all its parts—must be so—because of a common origin and a co-existence. This being so, the conclusion is inevitable that the elements composing it—its matter—are alike in all its parts—differing not in essence but in degree. As its members differ in size, these forces operating to the present, have only produced different states of matter. The entire system must have had a simultaneous origin, for its mechanism has never changed within the knowledge of man, nor has he found evidence that gives color to anything otherwise. Orbits have been eternal. Any difference in conditions must then have arisen from the differing volumes.

We are ignorant of what we call space—its forces, if any, and the influences flowing from it—and are thus confined to what we can discover of the various members of the system—or family of worlds. As the solar system is a unit, its origin the same, its matter identical, its laws uniform—its formation must have been so, and so of its development. One error has been that we take the earth as a globe of matter, and in contrast with the life upon it—dead. Is not this an error at the beginning? If, considering it a living thing, full of pulsating and circulating forces, being acted on and re-acting, do we not start with a clear apprehension of its phenomena? That

it is instinct with life, with unceasing and inconceivable forces in constant action reason teaches, and its relations with and obedience to the mighty laws of its planetary family, demonstrate.

In this light let us examine as to the origin of the atmosphere, as the logic of the formative process would suggest.

Taking the nebular hypothesis as true, or its modification, the hypothesis of nebular aggregation—the same for this purpose—and human reason aided by research has failed to find any other answering to what is known —let us follow the formation of worlds. The telescope reveals to us the cosmic cloud, star dust, which in some stage of development, must be of the material of the worlds. The mathematician has demonstrated that planets must be the result of such masses if rotating on their centres—condensing and giving off by the radiation of heat, a portion becomes the ball of matter that we inhabit, at the first a liquid globe, with all its matter in a fused and homogeneous condition. The more active radiation consequent on its separation from the general mass caused a crust to form. And this proceeding indefinitely, the elements most eligible for the operation of this force first becoming solidified, and so through the ages, proceeding by unchanging law. It was impossible in the beginning for life to exist, in any form, for the atmosphere was too intensely heated for its gaseous elements to form compounds, and it must have required ages of this cooling process before even oxygen and hydrogen could unite to form the vapor of water, by which the cooling process was accelerated, from the primeval rains which descended in incessant floods upon the heated mass.

And this intensifying the process, the action and re-action from the force thus evolved elude all conception in their awful power and sublimity —rending the crust and pulverizing rocks. These waters finally collecting into the depressions and basins formed by these throes of the primeval world, the thermal lakes and seas were formed as we find them in still cooler conditions in the age of man.

Still cooling, the elevated lands, seamed and scarred, began to be clothed with matter in new forms, and life in its lowest forms appeared—the facile elements had solidified into the earth, the obdurate remained as the atmosphere.

Thus was the world, as we know it, evolved from the original forms and fitted for the uses to which its author had dedicated it in the beginning.

That this must have been so, let us look out to our neighbors of the solar system and learn of them. We know that the planets possess atmospheres ; we know the sun's atmosphere. The spectroscope tells us of what these are composed. The atmosphere of the sun besides what our own has, is composed of what are the solids of our earth, so intensely heated that iron vapor is one of its largest constituents. We, too, had iron in ours. The atmospheres of Venus and Mars appear like our own—for the reason that their size and conditions of mass approximate ours. Jupiter and Saturn have atmospheres so different that it is highly probable these planets possess so high a temper-

ature as to hold many of our solids in a state of vapor, because, from their great mass, the cooling process has not reached the stage it has with us. And from all indications Jupiter is now in the condition described for our earth, in the period of the vapory condensation and rains. The moon shows no atmosphere that is perceptible from our methods—because from her size she must have so cooled as to condense all her matter—that her rocks have absorbed the oxygen and nitrogen, as the process is now going on in the nitre beds of our earth. This is not only possible, but by the law of planetary development must be so, from the properties of the atmosphere itself—for its most prominent physical property is that it is expanded by heat and condensed by cold—the latter if intense enough reducing all things to solids—and then the end. In degree we see this quality before us every day proclaiming the law.

That the atmosphere is the result of this condensation, or rather remains as that portion of the original mass which refuses the solidifying agencies, has support in the nature of the elements themselves. No agent, no resource has yet been found in chemistry powerful enough to change the conditions of pure nitrogen and oxygen. Nitrogen not only resists all efforts to change its form, but to unite it with other substances. It is persistent and unchangeable by any known appliance. Why then may it not be the result, or rather the residuum, of the forces which have transformed our earth from a glowing ball to the beneficent world we find it? And so of oxygen, another obdurate element, a little less so than nitrogen, therefore less in volume, and combining with hydrogen to form water; abundant in all matter, and when subject to the forces of nature, producing a concentrated form of itself, called ozone. Following the cosmic law, accepting the universally received hypothesis of the origin of the solar system, and its formation—can we account for the existence of the atmosphere upon any other theory than this? It seems from the premises logically inevitable.

That it is so analogy teaches—for in excess of either oxygen or nitrogen, life becomes impossible, beyond given quantities. And that the time was when they were in excess, we have abundant evidence, as in the case of nitrogen even, in the saltpetre caves and the vast nitre beds of some parts of the world, in which this stubborn element is imprisoned by a force greater than we know, and the oxygen in its varied combinations. When so reduced in volume, life as it exists was possible, and it came when the place was prepared for it.

If, then, this is the origin of the atmosphere, it suggests another thing. Being a part of the original matter of the earth, differing only in state from inherent properties of its own—being obdurate in the direction of solids while others are facile—it must not only be influenced by the same forces that influence the solid portions of the planet, but it must support its share of the circulating forces which give life and potency to it. And that it is so we gather in many ways.

Besides these two principal elements, we find in the air carbonic acid,

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ammonia, ozone, vapor of water and traces of other substances which have so far eluded the formulæ of the chemist. The presence of these substances, so easily managed as to make them common objects in the laboratory, demonstrates that they are introduced into the atmosphere, or mixed with it, from the earth. And the life of plants and animals—their processes of life evidence that from the immense quantities thrown off, or utilized, they must be re-absorbed into the circulation of the globe, or life would become extinct by their abundance overcharging the atmosphere with their noxious properties. For we must remember the nature of its chief components is to resist combination—their office is to diffuse, not absorb and change.

Then we come to the other phenomena, which are apparent to the senses only in their ultra manifestations—in storms, clouds, rain, thunder, lightnings. That these are impossible without direct connection, is so patent to the sense that they hardly need extended notice. The cloud discharges itself upon the earth, the earth responds to the cloud, and when intensely excited even earthquakes answer in sympathy, and declare the universal kinship of matter.

That the same currents of circulation pervade both, the response of the magnet to the splendors of the aurora attest, and even man by invoking this kinship can talk from mountain top to mountain top, as has been done, by simply asking the air to bear his messages—showing that the life currents of matter equally pervade the atmosphere with the more palpable elements of the solid globe.

That there is this intimate and constant relation between the earth and air—an absorption and emanation, so to speak—is better illustrated by the elements forming the smaller components of the atmosphere. And why should it not be so, when before our senses every day is shown that beyond all absorbents and disinfectants is mother earth, and beyond all diffusant mediums is the sustaining air. Take for example carbonic acid. If the supply is too small, life languishes, if over-abundant, death intervenes. That the supply is not everywhere and at all times the same, we see in the conditions of health in cities, and in marshy districts, and at certain periods; in the sometimes rank display of vegetation, and in places where no plant can live from its excess. It is exhaled into the air by animal respiration, by combustion of fuel, from decay of organic matter, from volcanoes, from thermal waters. It goes back through the leaves and by the roots of plants—but this is only one of the methods—it is stored in the coal measures, and the peat beds show that the process of storing it beyond the normal wants of life is keeping pace with the ages. That the atmosphere contained once immensely more than now, the saurian age, when only cold blooded animals could live on the earth, attests. Restore the carbonic acid of that period, and mammal life would become at once extinct.

Next is the vapor of water—its nature proclaims it an emanation and in constant flow from the earth. Then, we find ammonia, so intensely diffusive, and so strong in affinity for other substances, that its presence in the

rain, the snow and the dews, tells us at once how it is maintained in its proportion in the air we breathe. And now we find ozone, which perhaps of all the elements best illustrates the circulation of the earth and air. It is believed to be but a condensed or concentrated form of oxygen itself, compelled by a laboratory more powerful than any of man, and which has its seat in the earth. And it is the best illustration, because: (1) It is more abundant in the country than in cities and towns; (2) Its quantity is greatest in spring, less in the summer, decreasing in autumn, and least in winter. (3) It is most readily detected on rainy days, or after any great atmospheric disturbance.

Do not these facts point unvaryingly to the mutual action between the earth and atmosphere? Ozone is most abundant in the country, because the exhalation in cities is interrupted by houses, pavements and hard beaten surfaces. It is most abundant in spring, when the pores of the earth have been left open by the retiring frost, and it decreases in summer and autumn as these conditions become less, and least in winter when the whole face of the earth approximates the condition of cities. And it is more largely present after great atmospheric disturbances, because it is then that the effort of nature to restore the disturbed equilibrium is most active.

And lastly, we have the phenomena of epidemic disease, which is only to be explained by atmospheric causes—which are not carried by winds alone, because often traveling in the teeth of winds, and crossing continents in the very face of the trades, and on contrary sides of the globe, maintaining their same unvarying features.

That greater quantities of nitrogen, that element of the unknown office, than even now, once filled the air is evident, as well as that carbonic acid was once in greater volume—as the nitre beds referred to attest. Because we cannot with our glass retorts and furnaces harness this obdurate element, is no reason to conclude that the power which holds the solar system in its grasp, and which in the laboratory of the Sun evolves its iron into air, which sends vast globes in eternal rounds, with velocities that baffle imagination, yet holds them with the rein of mathematical obedience—that it is not equal to the task. Why stand we in awe of the giant power of nitrogen when imprisoned in its cruder forms of gunpowder and its kindred explosives, as it shakes the solid earth? and refuse to hear it when struck by the power of this occult force in midheaven, speaking to us in the voice of thunder, or when touched by the same power in the caverns of the earth admonishes us of its pervasive presence in all nature through the throes of the earthquake—upheaving mountains and depressing great areas of solid land.

Is it not as patent that these forces are from a common agent, as it is that the lava streaming out is glowing because of the presence of its twin element, oxygen?

If we will only accept this as probable, how much more rational becomes the solution of all these phenomena, than by the far fetched theory,

so palpably contradicted, that the earth is inert, that the atmosphere is a passive fluid—the one a stranger to the other—and all these wondrous exhibitions of kindred forces but the result of the Sun's rays, acting extraneously and without sympathy from elemental power, inhering in all parts and members of the solar system. That it must be so reason tells—facts demonstrate it—it cannot be otherwise. The earth is but a member of a common family—the atmosphere born of the same matter, obedient to the same law, controlled by the same force common to all—that force pervading every part of both—not solely induced by external heat. What is it?

This force, we arbitrarily call electricity. So far as human knowledge can take cognizance, it is that which pervades all matter, from the molecule to the planet, and binds all together. The trouble is that we reason from what strikes the natural senses, back to phenomena—we cannot eat or drink the air or the elements, hence we fail to realize them. But if we reason from them up to, or down to their ultimates, that we do use as ministers to our life, and life in all its manifestations, we become results, instead of their assuming the fragmentary form of phenomena of which our senses take cognizance. Science, from this stand-point enlarges our vision and adds to the capabilities of sense.

We now know that we must revise our theories—that the life of our world is only one form of the manifestation of matter and force—that behind it is a force or life more potent, of which it was born and by which it is controlled and maintained. That this force is what we call electricity there is no doubting—it is present in the atom and in the Sun, constant and the same—the life of worlds and of all divisions, elements and combinations of matter. That this force on the earth is excited and influenced by the heat of the Sun or through it upon other less intense forms of matter is beyond question. And now let us see if this is not the path to the secret of atmospheric phenomena?

Electricity, if not heat, is associated with it; if not light, it is with light in its operation—for it manifests both intense heat and light. If it is not in itself the law of chemical affinity, it is present with and controls it. If not magnetism, it is one of its modes of operation. If it is not gravity, it is always in its company. And if not itself the vital force of all nature and of vegetable and animal life, it is certainly coincident with and capable of controlling all. Briefly, as far as we know, it is the soul of matter, and its expressions are what we call its phenomena—whether in those limited to the field of our own earth or cosmical in their action.

The earth is a magnet, but not a natural one—but all bodies can be magnetized by currents of electricity flowing round them. We also know that the electricity of any body is excited and made to flow in currents by various causes:—by the disturbance of chemical affinity; by the decomposition of composite bodies; by the molestation of crystallized lamina, and also by the unequal heating of them—the electricity being excited in the heated part and flowing to the colder. And what now?

The earth is ever heated in part, ever cooling in part. The Sun is constantly shining on some portion of the globe, while another portion is continually in shadow. That portion on which the Sun shines at midday is warmer than that portion covered by mignight darkness—sometimes not less than sixty degrees difference. By the well known law of thermal electricity currents must be excited where the surface is heated and flow to where it is cooler—and thus we have currents always flowing from east to west—from where it is day to where it is night—for to the Sun the west is night. And by this current ever in flow, the earth becomes a magnet. This must be, but how far the magnetic ray of the Sun itself assists, is unknown—we only do know that the violet ray of the spectrum will render a needle magnetic.

Then again, constant parallel currents of electricity tend to converge, and thus produce intense action, and again they tend to produce secondary currents, and so on successively. By this method lateral currents are produced in or over the earth, as discovered by Faraday. These currents sometimes become so intense as to produce what Humboldt calls magnetic storms, from which comes the Aurora—so powerful at times that the telegraph can be worked without the aid of batteries.

All currents of electricity passing through the air, tend to displace it, and to create currents in it. Here are the inducing causes of the winds, varying according to electrical activity, from the breeze that gratifies to the tornado that is carried forward with such amazing velocity and such terrible power. That it flows from the earth to the air conducted by the same properties of matter, can be even seen at times by the naked eye—from trees, from mountains and every object that elevates itself above the common level of the mass of the earth—as well as on the sea from the masts of ships.

The discoveries ot Meissner and Faraday, as to the magnetization of oxygen, leave no further doubt that evaporation is to a great extent an electric process, aided by heat, but acting independent of it. Dr. Kane tells of thaws in the arctic regions during the long polar nights, when no ray of Sun had visited them for weeks. And Captain Hall, on the farthest point ever reached by explorer toward the pole, was gladdened by the far northern horizon banked with nimbus clouds. This vapor when evaporated is combined with the oxygen and electricity, and exists by that force in the atmosphere. This acted upon, by static or inductive forces, perhaps, condenses, and clouds are the result. It takes place, we see, as readily in the depths of the arctic night as in the heated atmosphere of the tropical day. And the artic storm, which by this vaunted law, should be the result of heat, by its icy breath destroys even lichen life and howls in those awful solitudes, amid crashing icebergs and the groaning ice fields with a power that surpasses the storm revels of the tropics.

Dynamically, the heat of the Sun is incompetent to this task even under the most favorable conditions. I must return to this theory once more, to

give it a parting word. Its advocates tell us all these awful manifestations come from the ascensive power of heated air, but experiment has demonstrated that even air, confined so as to prevent the operation of the law of diffusion and expansion, which are free to act in the atmosphere, where heated to 100° above surrounding air, exerts a force of only one-third of an ounce to a square foot. Yet forests have been prostrated, cities wrecked, and navies stranded when the thermometer showed but 70°. Is it possible science has endorsed such a stupendous illusion as this? Why not instead look to this other source for the daily atmospheric phenomena, all over the globe? The electrical current is uniform, the heated air theory is not—the results, varied and incessant, are in harmony with the electric law, which is constant but in varying intensity. The one is harmonious and consistent, the other uniform only in its inconsistencies. Every day we see the evidences of the electric flow—even the shivered tree tells its story that the positive cloud and the negative earth have established the electrical equilibrium, leaving it to be a witness that man may learn. We are told the same fact by influences upon animal life long before the disturbing cause has become patent to the sense. Cackling geese saved Rome, but their cries preceding a storm have told the rustic for ages what science has shut its eyes to for centuries. Even the unpoetic pig has discovered the fact, and in obedience to the law makes his bed warm long in advance. Can we not learn of facts as well?—that these are the warnings of electrical conditions, not of tropical heats 2,000 miles to the south of us.

But to return. Even the oscillations of the barometer are now found to be influenced by electric currents, for it has its maxima and its minima, entirely independent of temperature—tides of the atmosphere as there are tides of the sea—induced by electric tension of the air. And as intimated before, it is more than a question whether clouds themselves are not the result of electric process instead of cold—or that cold is only one of its agents, but not indispensable.

It is by no means settled that magnetism does not promote cold, and that in this form of electricity we may not find the factor which has always been evoked from unknown and unknowable space. If so, then the circle is complete That "cold is the absence of heat," has been the extent of our knowledge, is proverbial, but if cold, too, is found to be but one form of the manifestation of this mysterious force, then will meteorology gain new elements for the fulfillment of its ambition as an exact science.

We do know that the magnetic intensity of the earth differs—it is not uniformly distributed. There are magnetic poles, and we find that there are lines of greatest intensity, passing from these poles and connecting with like poles in both hemispheres. They are known as lines of no variation—or where the needle does not dip. Facts show that these lines affect the meteorology of that portion of the earth through which they pass—as the stormy Atlantic and the peaceful Pacific seas attest, as well as the climatic conditions of their coasts.

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But the important fact is that these magnetic poles are poles of cold. All the isothermal lines of our hemisphere are affected by these poles, or area of no variation and greatest intensity. Take a globe, with the isothermal lines drawn upon it, and looking down from above the north pole, and this fact strikes the observer with startling force. That seas and elevations have their effect upon these lines of temperature, is undoubted, but that they are intimately connected with the magnetism of the earth, or that its temperature is affected by these poles, is too apparent to be rejected.

But this topic can be followed no farther—for a paper of this scope must have a limit—it, however, indicates the way for the completion of the law.

In this vast field, it was necessary to be discursive, and that is the view presented. I have not pretended to have a theory, or to account for the phenomena of the atmosphere. That much of what has been said is of course crude and undigested, is too true. The only object has been to set forth some facts, which have from time to time forced upon the mind the conviction that the old and generally accepted theory of the atmosphere and its phenomena was not the true one. That at best it was but a partial presentation of the causes underlying these phenomena—and as a law utterly without the authority of facts to sustain it, and that we must look elsewhere for light, which after nearly two centuries of following this theory has ended in deeper darkness.

If, then, the solar system had a common origin—which the common law it obeys declares—its matter is the same; that its constitution as to its members varies only in degree; that the law of the atom is but the law of a world, and the force that travels with the sun, the same that abides with the sun itself, and in all its family of worlds. That life is the law of matter, and that the planets have their life, as we that live on them have ours —that one is the result of the same law, or power, as we may call it, as the other,—the one world differing from the other only in degree.

That if the solar system was the result of force, acting on nebulous matter, our atmosphere is as much a part of that nebulous matter as the rocks —that both are the result of the same force which we call radiation, or cooling—and that it is composed, mainly, of those elements immutable to the forces that formed the solid globe or liquid waters. That at a period in this process, life as we know it was impossible, and that life came when the conditions made it possible. That the process is still going on, or, that the forces which once operated on the primal nebula have in the long ages of their operation produced such an equilibrium of matter, so adjusted its functions as to make the elements as a whole, self compensating, self-conserving, and thus self-perpetuating and eternal—for the purposes of this paper not requisite to know or to inquire.

That the air and earth, thus of the same origin, are for planetary purposes identical, and controlled by forces which impart the properties or

influences of the one to the other. That the atmosphere supports life—at the bottom of the seas as in the air itself. That it not only surrounds the earth, but permeates it, imparting life and drawing life to itself, and that the influence evolved in the one is felt in the other, and that both reach out to their sister elements in the great family of the solar system.

This being so, the phenomena we see—of heat, cold, clouds, rain, calm and storm, the winds and the tornado, all flow from the manifestations of the life of the system itself—the revelations of the life currents of earth, whose results we see in them, and whence we know they exist—but which itself we cannot know, or have been unable as yet to discover or fully understand.

That the heat of the sun is a powerful factor in all this life, admits of no doubt, but that this globe has within it energies of its own, we may say latent heat of its own, which acts responsive, is beyond the power of mind or intelligence to doubt.

METEORIC STONES AND SHOOTING STARS.

BY PROF. G. C. BROADHEAD, PLEASANT HILL, MO.

The phenomenon of Falling Stars or Meteoric Showers, and Aerolites or Meteoric Stones and Bolides, is one that is least understood of celestial phenomena, yet one that is near us and at all times interesting to the scientist. They flash before our vision with dazzling brilliancy, apparently burst and disappear. Some are gaseous and of course transparent, others are solid, as the Bolides.

Meteoric Stones are liable to fall at any time, but at certain periods of time shooting stars are more likely to be seen. Every year about the 10th of August, a shower of meteors is seen that appears to proceed from the constellation Perseus. Another period of the 12th and 13th days of November, after thirty-three years, and for three years thereafter, at which time they apparently proceed from the Constellation Leo. The next periodic appearance of the November shower will be in the year 1900.

Besides these two principal showers, it is estimated that there are nearly one hundred others recurring at regular intervals, and each a cosmical cloud of dark bodies, loosely held together and circulating around the Sun in a common orbit*

Schiapparelli, Le Verrier and others, give as their conclusions, that meteors are fragmentary masses revolving like the planets round the Sun in a regular orbit, which, in its course, approaches the orbit of the Earth, which is intersected by their orbit at this regular period, and are drawn by its attraction into our atmosphere, and are there set set on fire by heat generated by the resistance offered by the compressed air.

Schiapparelli also came to the conclusion that the same object at one

* Schellen.

time may be a comet, and at another time a shower of meteors. He first observed that a large and brilliant comet which appeared in 1862, crossed the path of the Earth's orbit in the very region in which the August meteors appeared. His investigations proved that both the comet and the meteors had traveled along the same path. But with much study and observation it was some time before an attendant on the November train could be found. At last Peters found that a telescopic comet did in fact travel the same path as that of the November meteors. These facts at least showed that close relations existed between comets and meteors, and caused astronomers to study more closely.

Adams demonstrated that the zone of cosmical bodies forming the meteor system, had an orbit extending out into space beyond the orbit of Uranus, and the opinion of some astronomers is, that to Uranus do we owe the attraction of these star showers.

The various meteor systems appear to proceed from or near some fixed point in the heavens. Besides the radiant points above named, there is a prominent shower of November 27, that appears to proceed from (*Gamma*) Andromedæ.

Meteors chiefly appear between 46 and 92 miles elevation, (mean, 66), their speed varying from fourteen to one hundred and seven miles per second. A majority of the November meteors seen in 1868, appeared of an orange color, a very few blue.

In 1866 the portion of the stream of November meteors through which the Earth passed, was 80,000 miles deep. In 1867, the Earth traversed a shallow part of the stream, or 50,000 miles.* Prof. H. A. Newton estimates the thickness of the August ring at five to ten millions of miles; for the Earth moving at the rate of two millions of miles per day, is immersed in it for several days, and in two hundred and eighty-one days, periodic time, he estimates more than 300,000,000,000,000 for the total number in the August ring.† Prof. Twining (‡) says: "The conformable meteors of November and August are chiefly to be distinguished from ordinary shooting stars by a massive aspect resulting from a more ardent and copious combustion. They are further distinguished by their numbers and relations to a radiant. Those of ordinary nights also sometimes pursue an erratic course, darting off laterally at the end of their appearance, or waving from side to side, sometimes even appearing to expire twice.

THE NOVEMBER SHOWER.

Humboldt gives the following catalogue of the appearances of the November 13th shower:

1787.....	November	9-10	1846.....	November	12-13
1818.....	"	12-13	1847.....	"	12-13
1822.....	"	12	1849.....	"	12-13
1823.....	"	12-13			

* Eclectic Monthly, February, 1870.
† American Journal of Science. ‡ American Journal of Science, January, 1863.

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A star shower is chronicled in Germany as appearing November 15th, 1606, seeming as if it rained stars, first the largest and brightest, and then both large and small ones, becoming extinguished before reaching the Earth†

An early record was that of a meteoric storm A. D. 902. Later one of November 9, 1698; of November, 1833, and November 14, 1866. From these data it was at once known that the period of the November shower was thirty-three years.

Other displays referred to the November shower were:

October	18.5	A. D. 903	October	29.5	A. D. 1366
"	19	" 931	Novem'r	3	" 1533
"	19	" 934	"	8.6	" 1698
"	20	" 1002	"	11.6	" 1799
"	24	" 1101	"	12.7	" 1833
"	26	" 1202			

Arago estimated that during three hours of the 12th of November, 1833, there passed over 240,000 meteors. Many persons can now remember that it was a very remarkable shower. So remarkable was it in its brilliancy and number of stars, as to be a source of terror to many of the ignorant, who imagined the final day of all things had arrived.

It has been assumed by astronomers, based on observations made, that seven and a half millions of meteors pass the Earth's atmosphere, and bright enough to be seen by the naked eye, every twenty-four hours; or, if revealed by the telescope, would number four hundred millions.‡

METEORS OF NOVEMBER 27.

At Teneriffe, Canary Islands, on the 27th of November, 1872, five hundred meteors were seen to fall in the space of half an hour. At 11:30 P. M., November 29, the rooms of the American Consul, Mr. O. F. Dabney, were suddenly illuminated by an intense blueish white light, lasting for several seconds. It was apparently brighter than the moonlight, becoming red, and then vanishing. About four minutes after a report was heard similar to that of a large piece of artillery, shaking the house and reverberating for some seconds among the surrounding mountains. Persons saw this meteor as a luminous body of conical shape, going with great velocity, point foremost, and drawing after it a long fiery train.*

The above-named shower of the 27th, was also observed under very favorable circumstances, by Padre Denza, at Moncalieri, Italy. It was apparent from dusk until after midnight, during which time of six hours, 33,400 meteors were counted by four observers. But this really did not include the total number passing, for in the first hour of the night, and especially in the hour of the maximum fall. 8 o'clock, there was in some regions of the heavens truly a rain of fire, so that it was impossible to count any but the most remarkable. Padre Denza speaks of this as a very won-

† American Journal of Science, September, 1863.
* American Journal of Science, August, 1873.
‡ Scheller in Half Hour Recreations.

derful and beautiful phenomenon, some meteors showing the most varied and delicate colors; many were followed by broad and brilliant tracks of fire, very frequently balls of a dazzling white, and with a diameter but little less than that of the moon, were seen. The general aspect was that of a cosmical cloud, which, encountering our atmosphere, was broken in pieces and scattered. The position of the radiant was near (*Gamma*) Andromedæ.

Denza considered it a regular periodic shower, the same seen by Brandes 7th December, 1798, by Abbe Raillard December 7, 1830, by Herrick and Flangorgues in 1838, also recognized at Bergamo in 1867. In 1872 its point of contact with the earth's orbit should fall on November 27–28.

This shower of November 27, 1872, was also seen at Turin, at Rome, at Palermo, at Naples, at Messina. At Matera, Prof. Vito Eugenio with three assistants counted 38,153 meteors in six hours. The maximum took place everywhere between 8 and 9 o'clock, and the radiant was found to be not far from (*gamma*) Andromedæ.

This display was observed in Egypt and well noted in England. E. J. Lowe, of Nottingham, enumerated 58,660 between 5 h 20′ p. m. and 10 h 30′ p. m., and observed the radiant point to be (*gamma*) Andromedæ. Near the radiant point the meteors were the smallest and had the shortest paths. All had tails, but only the largest were observed to vary in color. Several times during the display reports were heard, resembling that of distant shot guns.

At Athens, Greece, about 25,000 were counted during nine hours, and Dr. Schmidt stated, that while the shower of November 13, 1866, was remarkable for its brilliancy, its numerous bolides, the slenderness and brightness of the trains and preponderance of green colors, that of November 27, 1872, was entirely different, the stars were chiefly faint with broad smokelike trains and colors between white and reddish yellow, and motion apparently slow and undecided. †

This shower of November 27th was also observed at numerous stations in the United States, beginning on the 24th, but there were not so many counted. Their point of radiance was from (*gamma*) Andromedæ.

Old Lusatian chronicles report that on 3d December, 1565, there fell at Soran fire from heaven like flakes of snow. ‡

Prof. Newton‖ supposes that the meteoric showers were at one time all connected with periodic comets and the scattering took place at or near their perihelion. A startling telegram from Prof. Klinkerfues on the night of November 30th, 1872, ran thus: Biela touched the earth on the 27th. Astronomers state that in 1872 Biela's comet disintegrated and appeared as a star shower. Prof. Newton§ gives data showing that the November star shower has a motion along the siderial year of one day in seventy years, and the dates of the earlier showers show that the true period does not widely differ from the siderial year.

† American Journal, February, 1873.
‡ American Journal, May, 1868. ‖ American Journal, January, 1873. § American Journal. July and September, 1864.

OTHER PERIODS.

Schiapparelli cites a shower whose point of radiance is in the Northern Crown, and time April 30th to May 1st. Prof. Daniel Kirkwood has determined the period of this display to be about seven years, and thinks that it corresponds with the following list of displays:

April 9	A. D. 401	April 17	A. D. 927
" 17	" 538	" 18	" 934
" 17	" 839	" 16	" 1009*

August Meteors.—Francis Bradley in going from Davenport, Iowa, to Chicago, Ill., August 9 and 10, 1858, observed 128 shooting stars, whose radiant point was at or near Perseus. †

Prof. Twining observed at New Haven, Conn., August 10, 1861, at 11½ p. m., a meteor beginning near (*Epsilon*) Cygni, which appeared very brilliant for 12 seconds. Mr. Herrick says, we were startled by a brilllant flash, immediately followed by a bright phosphoric bar, the meteor having suddenly vanished, which was visible for 20 seconds, thus indicating a visible track of 33 miles and altitude of 70 and 54 miles, with a velocity of 26.6 miles per second.‡

On 10th December, 1862, at 10½ to 11 p. m., a half dozen meteors were seen at Philadelphia, apparently radiating from Castor and Pollux. The next morning, from 4 to 4½ a. m., a few more were seen also, all radiating from the same point.

METEORIC STONES.

We have thus far been speaking of Meteorites as bodies having some definite motion. Bolides or Aerolites are reckoned by some persons to be governed by the same laws and to have periodic revolutions, but others, and even our best scientific men, choose to think differently. Investigations prove that the laws of crystalization affecting them are the same as those affecting terrestial matter. || Thus we find pyroxene, olivine, chrome iron, angite, &c., as constituents of meteoric bodies. Their form is very irregular and of various shapes, going to prove that the individual meteorites have not always been cosmical bodies, for otherwise their form would have been spherical or spheroidal. They must, therefore, at one time, have formed part of a larger mass.

Sulphurets and phosphurets of metals are also found in the interior of the mass, arranged in nodules completely separated from the mass. ||

Meteoric stones may be (1) metallic, (2) stony, (3) mixed. The rocks or minerals of meteorites are not of a sedimentary character, nor such as are produced by the action or agency of water. The stony meteorites all have a dark colored coating, which has been formed upon them after they entered our atmosphere. Metallic iron alloyed with more or less nickel and cobalt is of almost constant occurrence in meteorites. The existence of this highly oxydizable mineral in its metallic condition is a positive indication

* American Journal, July, 1872. † American Journal, November, 1858.
‡ American Journal, November, 1861.
|| Dr. J. L. Smith, Scientific Researches, p. 285

of a scarcity or total absence of oxygen (in its gaseous state or in the form of water) in the locality whence it came. The stony portions resemble the older igneous rocks, and very closely those of some active or extinct volcanoes. Phosphorus is frequently but not always associated with the iron.† Iron, nickel, cobalt and phosphorus are almost constant constituents, and Dr. J. Lawrence Smith states that in only three or four, out of some hundreds, they were not recognized; and none of these minerals are associated with oxygen; and excepting copper, none of them are even found upon the earth without oxygen. Phosphorus is probably always an associate of meteoric irons.

Although analysis reveals that meteorites do contain a few minerals unknown to our earth, still these minerals may be resolved into their simple elements such as we are familiar with. Besides the above constituents they contain oxygen, hydrogen, sulphur, phosphorus, carbon, aluminium, titanium, lead, manganese, calcium, sodium, potassium, magnesium, lithium, strontium; also olivine, augite, tin, and chromium.

Dr. J. Lawrence Smith considers that enstatite, bronzite and chrysolite form 90 per cent of the earthy minerals in the aggregate mass of all meteoric stones.‡

Schreibersite and Troillite, two minerals not found in the earth, are found in meteorites. Schreibersite is a phosphuret of iron and nickel, with traces of copper and cobalt. Troillite is a protosulphid of iron, with sometimes traces of nickel and copper.

Some scientific persons proclaim the theory that solid meteors have been ejected from the moon, others that they are formed from particles collected in the atmosphere. The theory of others, is that they are small planetary bodies revolving around the sun, one portion of their orbit approaching or crossing that of the earth, and, being small bodies, approach too near our planet and fall to the earth's surface. This presupposes their having always had an individual cosmical existence.

Terzego in 1660 and Olbers in 1795 advanced the lunar theory, which was supported by Laplace up to his death. Berzelius, Arago and others also held the same views, but in 1836 Olbers discarded it and adopted the cosmical theory.

The average specific gravity of meteors is claimed to be about the same as that of the moon, as also their chemical composition. Astronomers say that a body projected from the moon with a velocity of about 8,000 feet per second would go beyond the mutual point of attraction between the earth and moon. Dr. Peters, who made observations at Mount Ætna, estimated that the velocity of some stones was 1250 feet per second, and observations at Teneriffe gave 3,000 feet per second.*

WIDMANSTATTIAN FIGURES.

There are certain lines resembling scratches, developed on the smooth

† Scientific Researches, J. L. Jmith, p. 287, 288.
‡ Scientific Researches, p. 376.
* Scientific Researches by J. Lawrence Smith.

surface of iron meteorites peculiar to them, and thus far never found on any other stone or metal. They are called Widmanstattian figures. In the Bates County, Missouri, méteorite they consist of four systems of lines, those in each system parallel to each other, and crossing those of the other systems at obliques angles. To obtain these lines it is necessary to thoroughly polish the surface of iron, then lay on nitric acid, rub this off and the lines appear. (See p. 741.)

SIZE OF METEORITES.

The Bates County Iron meteorite was a little over 85 lbs. before being cut. The Tazewell, East Tennesse Iron meteorite was 55 lbs. That of iron from Coahuila, Mexico, fifty miles northwest of Santa Rosa, and now in the Smithsonian, 252 lbs. Tucson, Arizona, of iron, 1400 lbs. Eight others from Coahuila, obtained by Dr. Butcher, from 290 to 800 lbs. A mass of meteoric iron now in Chihuahua, weighs about 3,853 lbs. Probably the largest known meteoric mass is of iron, and discovered by Dr. John Evans, in Oregon, in the mountains east of Port Orford, and supposed to weigh several tons.

The San Gregario, Chihuahua, meteorite weighs 1006 lbs. A mass of meteoric iron near Melbourne, Australia, is said to weigh five to six tons; another mass near by weighs one and a half tons. The Gibbs meteorite in the Yale College cabinet, weighs 1635 lbs. It was brought from Red River. Don Rubin de Celis discovered one in the District of Chaco-Gualamba, South America, whose weight was estimated at 32,000 lbs. There is another at Bahia, Brazil, whose weight is 14,000 lbs. The Siberian meteorite found by Pallas, weighed originally 1,600 lbs., and contained embedded crystals of Chrysolite.*

A mass of meteoric iron from Greenland, weighing several thousand pounds, was on exhibition at the Centennial. A Swedish Scientific Expedition to Greenland, in 1871, brought away twenty large pieces of meteoric iron. The largest, of 21 tons, was deposited in the Royal Academy, Stockholm; the next, of nine tons, at Copenhagen.

CATALOGUES OF METEORITES.

Dr. Otto Buchner, Leipzig, 1863, catalogues the fall of 153 stony meteorites, commencing with a fall of Nov. 16, 1492, and ending Oct., 1862.

The various cabinets of the world included in 1863, the following:

Vienna	194	Gottingen	125
London, (British Museum)	190	Paris, (Garden of Plants)	53

The largest private collections:

R. P. Gregg, Manchester, England	191
Reichenbach, Vienna	176
Neville, London	101
Auerbach, Moscow	76
Newman, Prague	61
J. Lawrence Smith, Louisville, Kentucky	60
C, U. Shepard, Amherst College	151†

* Dana Mineralogy, p. 16. † American Journal of Science, November, 1863.

In 1876 Prof. J. Lawrence Smith had 171 in his collection, and in 1872, C. U. Shepard had 143 stony and 93 Iron Meteorites.

REMARKABLE FALLS.

A meteor, or rather a small group of meteors, were observed at New Haven, Conn., at 6 P. M., February 14, 1873. They appeared near Venus, moving northward and downward. There were two balls, the leading, smaller one, bright green, the following one a yellowish color. At New Britain, Conn., it was seen to divide into two portions, and one or two smaller ones; the latter soon vanished, the other two passed on.‡

Dr. Schmidt, at Athens, Greece, October 18, 1863, saw what appeared to the naked eye, a single meteor, but the telescope revealed two large meteors, traveling in front of a number of small fire balls, each of which was followed by a train. Dr. Reinsun observed by means of a telescope, three small meteors, separated frem each other by small dark spaces; the two in front smaller than the third, and the three presented the appearance of a small isosceles triangle, with base in front.

A brilliant fire ball was seen at Montpelier, Vermont, July 17, 1818, between 9 and 10 o'clock P. M. It was a pear-shaped ball the size of the full Moon, with its broader end towards the Earth, and immediately followed by two smaller fire balls.

On June 14. 1871, R. H. Thurston, U. S. N., saw on the deck of a vessel between Providence and New York, a sudden flash of bright blue light, instantaneously succeeded by an equally intense red flash, which again gave place to a blue. A nucleus appeared with a long hair-like train of a bluish color, becoming red on the south side; it disappeared 21° above the horizon.*

A meteor was seen throughout Germany, from Halle to Vienna, three hundred miles distant, at 7 o'clock P. M., December 3, 1861. The length of its path was eighty eight miles; time of flight, two to five seconds, and was about three hundred miles elevation when first seen, and exploded at an elevation of fifty-seven miles, into three pieces. Its diameter was about nine hundred feet, and brilliancy equal to that of the full Moon, increasing to three times that at Vienna.

A meteoric stone weighing 12 lbs., was seen to fall in Hungary at 3 P.M., October 13, 1852, which buried itself in the ground two feet. Near Batsura, India, on May 12, 1861, a sound was heard resembling a cannon, succeeded by several successive peals of seeming thunder. The noise was heard for sixty miles. Five stones were picked up at various places, about three miles apart, one of them having buried itself in the ground about eighteen inches.†

At 9:30 A. M., November 15, 1859, a meteorite fell with a tremendous explosion in the southern part of New Jersey. It was seen from Newburyport, Massachusetts, to Petersburg, Virginia. Its apparent diameter

‡ American Journal of Science, April, 1873.
† American Journal of Science, July, 18 3.
* American Journal of Science, January, 1871.

appeared to be somewhat less than that of the Sun. At New Haven it appeared about 12° high or thirty-six miles; in New York, 35°; at Alexandria, D. C., 40°; disappearing near Tuckertown, N. J., at 10° elevation. Its visible path was estimated to be 15° to 25°, and velocity eighteen to thirty-six miles per second, being visible two seconds at Alexandria. Its disappearance was attended with a sudden flash of light, leaving a smoky column, which soon vanished. A minute after the flash, a series of terrific explosions was heard, which were compared to the discharge of a one thousand pound cannon; this continuing for about two minutes.

Meteor of July 20, 1860.—This was visible for at least a thousand miles in length from N. N. W. to S. S. E. by seven or eight hundred in width; or from Lake Michigan to the Gulf stream and from Maine to Virginia. Observations at New Haven determined its path S. 28° W. with a maximum altitude of 53° and time of flight 10 to 20 seconds. At Meadville, Pa., its altitude was 39° 30′ from the northern horizon, disappearing at an altitude 3° 30′. From the various observations it was determined that the vertical plane in which the meteor moved cuts the earth's surface in a line crossing the northern part of Lake Michigan, passing through Buffalo, Elmira and Sing Sing, N. Y. Greenwich, Conn., and across Long Island into the Atlantic. Its nearest approach to the earth, 41 miles, was a little south of Rhode Island, 44 miles over Hudson river, 51 at Elmira, 62 at Buffalo, 85 over Lake Huron, 120 over Lake Michigan.

It was first seen as a single body, gradually increasing in brilliancy, throwing off occasional sparks and flashes of light. Reaching Elmira an explosion occurred, the meteor separating into two principal portions and other subordinate fragments, but continuing on their course in a line behind each other, but continuing to scatter luminous sparks, until reaching a point south of Nantucket when a second explosion occurred, the principal fragments passing on.

The entire velocity was estimated to be from 8 to 15 miles per second. Probably 12 to 13 miles would be nearly correct. And allowing for the earth's motion in its orbit would give 26 to 27 miles per second as the actual velocity of the meteor in space. The apparent diameter of the luminous mass was nearly that of the moon, and its actual diameter from one fifth to one third of a mile. †

Meteor of August 2, 1860.—Prof. Newton in *American Journal* of May, 1862, gives an interesting account of the appearance of a meteoric fire ball which first became visible over N. E. Georgia near N. lat. 33° 50′ W. long. 82° 40′, at about 82 miles elevation above the earth's surface; passing N. 35° W. for 240 miles, when it exploded at an altitude of 28 miles over the southern boundary of Kentucky, nearly over N. lat. 36° 40′, W. long. 85° 05′. It was seen from Pittsburgh to New Orleans and from Charleston to St. Louis, an area of 900 miles extent. It was seen in West Virginia, at Marietta, O., Cincinnati O., Bloomington, Ind., St. Louis, Mo., Bowling Green, Ky., Nashville, Tenn., Montgomery, Ala., Holly Springs, Miss.,

Charleston, S. C. The duration of flight 'was variously estimated from 6 seconds to 30 seconds, but was more probably 7 or 8 seconds, for the whole line, which would be from 30 to 35 miles per second. Explosions were heard echoing like thunder from 3 to 5 minutes after at Knoxville, Rome and Pitts' Cross Roads, Tenn.

Some accounts make the apparent size of the meteor larger than that of the moon. Visible explosions were observed during its flight, during which multitudes of sparks were thrown off. In connection with this Prof. Newton considers that those meteors whose velocities are relatively great are burnt up or dissipated before reaching the ground; those whose velocities are slow furnish aerolites.

Meteor of August 6, 1860.—At 7 h 38′ New York mean time, a fire ball about as brilliant as Venus was visible from Pittsburgh, Pa., to Roxbury, Mass. Near the middle of its course it appeared to distant observers to separate into two parts, while those who were nearer saw it continually giving off fragments. Its time of flight was about 6 seconds, and velocity about 14 miles per second.

It first appeared 39 miles above the earth, nearly over the southern line of Pennsylvania, in N. lat. 39° 35′, W. long. 76° 45′, and passing N. 80° W. to a point 36 miles above the earth and west of Buffalo where it was last seen. The total length of its path was 250 miles. ||

Dr. J. Lawrence Smith, in his scientific researches, speaks of a meteorite that was seen to fall two miles west of Petersburgh, Lincoln county, Tenn., at 3:30 P. M., August 5, 1865, during or just after a severe rain storm. It apparently came from the east, and while falling, appeared to be surrounded by a milky halo. Its fall was preceded by a loud report, resembling that of a large cannon, followed by four or five lesser reports. It was buried eighteen inches in the ground, and was of small size, only fourteen and a half ounces, of an ashy-gray color, varied by patches of white, yellowish and dark minerals, and incrusted with a black shiny coat. It was magnetic, with a specific gravity of 3.20. It contained Pyroxene, Olivine, and Orthoclase, disseminated. Nickeliferous iron formed half per cent. of the mass, and nickel a very small quantity.

Several meteorites of similar appearance were seen to fall at Danville, Ala., at 5 P. M., November 27, 1868. A piece weighing four and a half pounds was buried one and a half feet deep in the ground. It contained three per cent, of iron, with a very small per cent. of nickel and cobalt, and had a somewhat oolitic structure.

The Searsmont, Maine, meteorite, which fell May 21, 1871, at 8 A. M., was embedded two feet in the ground and broken into several fragments. Its total weight was twelve pounds. It contained of nickeliferous iron, 14.62; stony matter, 85.38 per cent.

Dr. J. Lawrence Smith observed at Louisville, Kentucky, just after sun-

† C. S. Lyman in American Journal, September, 1860.
‖ H. A. N., in American Journal of Science, May, 1862.

down on the 12th December, 1874, a large red light suddenly appearing in the zenith, and for several seconds seemed to stand motionless, it apparently descending directly in a line to the observer; then starting off with an uncertain, fluttering motion, it moved slowly towards the horizon in a southerly direction, gradually fading in its flight, from a lurid red to a dark purplish hue, and leaving a dense stream of blue smoke behind, which remained for several minutes after the disappearance of the meteorite. An observer, eighty miles east of Louisville, saw it appear almost due west, about 30° above the horizon, and moving rapidly southward, inclined to the horizon, and disappearing about 20° above it, leaving a bright track of smoke, at first very luminous, soon fading as the Sun descended lower, then seemed to be wafted into zigzags by a gentle breeze, curling up in folds and disappearing. Four or five minutes after, three or four loud detonations were heard in quick succession.*

Guernsey County, Ohio, Meteorites.—This remarkable fall took place May 1, 1860. At Cambridge, in Guernsey county, Ohio, (lat. 40° 4′, long. 81° 35′), about twenty minutes before 1 P. M., three or four distinct explosions were heard, like firing of heavy cannon, with an interval of a second or two between each report. This was followed by sounds like firing of musketry, ending with a rumbling sound like distant thunder, which lasted for two or three minutes. The meteors were seen to pass and heard by persons in Washington, Noble, Guernsey and Muskingum counties, Ohio, and at Parkersburg, West Virginia. Houses were shaken at Parkersburg as if by an earthquake, and throughout the path in the above named counties. The direction of the meteorites was from southeast to northwest, striking the ground at an angle of 60°. Prof. Evans calculated its velocity to be about four miles per second. In Washington county, near Noble, it was about forty-three miles high, and nearly forty-one miles over Noble county, a few miles south of Sarahsville. About this point of its patch it exploded, the fragments passing on struck the ground at various places in the southwest part of Guernsey couunty. Soon after falling they were quite warm. Thirty fragments of various sizes from half a pound to one hundred and three pounds were picked up. The stones had a coarse gray appearance, with a black crust, and contains: Nickeliferous iron, 10.7; earthy minerals, 89.3. The nickeliferous particlès contain minute traces of cobalt, copper, phosphorus and sulphur.†

Iowa County, Iowa Meteorite.—Mr. C. W. Irish, of Iowa City, in an interesting pamphlet, informs us that this meteor struck our atmosphere at 10:20 P. M., February 12, 1875, in N. lat. 40°, W. long. 93°, over the northern part of Missouri; it moved from South to North, curving eastwardly, and exploded in N. lat. 40° 53′, W. long. 91° 40′; its visible path being 112 miles north and 47 miles east, and was visible about ten seconds. Observers say that its light was very intense, the nucleus round and as bright almost as the Sun. It sparkled and quivered like the twinkling of a star, with now

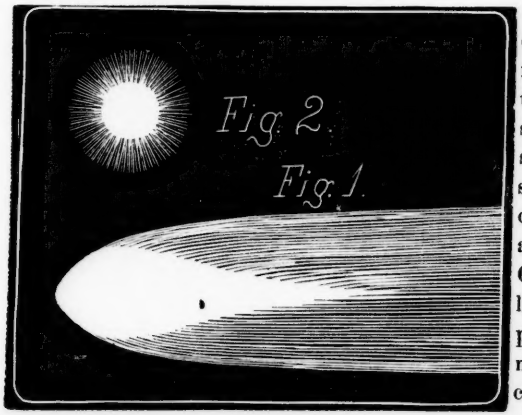
* Dr. J. Lawrence Smith, in American Journal of Science, Sept. 1875
† Dr J. Lawrence Smith's Scientific Researches

and then a vivid flash. Its size and motion seemed to increase towards the zenith, when it seemd to start suddenly and dart away on its course. All observers who were in twelve miles of the line of its path, say it threw down sparks which drifted eastward. Their clouds of smoke or vapor followed in its track, at times overtaking it, and then were lost. A bright deep red with flashes of green and other prismatic colors, appeared around the nucleus or at the forward part of it. From three to five minutes after vanishing, observers near the south end of its path, heard an intensely loud and crashing explosion; this was followed by a rushing rumbling sound that seemed to follow the path of the meteor, and at intervals, as it rolled away northward, varied by sounds of distinct explosions, growing fainter as it continued, until at last it died away in three to five explosions, much fainter than the others. One and a half to two minutes after, five quickly recurring reports were heard, reverberating with terrific force, quickly succeeded by and almost blending with these reports, came hollow bellowings and rattling sounds.

The meteor was seen at Red Wing, Minnesota, 186 miles; at Rockford, Illinois, 150 miles; at Omaha, Nebraska, 190 miles; and at St. Louis, Mo., 214 miles distant from the nearest point of the path.

On its path a large mass was separated from the main body and then exploded into many pieces, and passing on about thirty-two miles, fell, the various pieces scattering over the surface for six miles long by one and a half miles wide, falling near Marengo, Iowa county, Iowa. About 150 pieces were picked up, aggregating not less than 500 pounds. Mr. Irish estimated the velocity in our atmosphere at twenty-one miles per second; also, that before it divided it was about forty feet diameter, with a train of 9°, or seven to twelve miles long.

The annexed cuts, copied from Mr. Irish's pamphlet, and by his permission inserted here, show the appearance of the meteor as seen from two directions at right angles to each other. Figure 1, as seen from persons west of it, and Figure 2, as seen by persons in front.



The greatest diameter of the white portion is forty feet, and of the meteoric mass 100 feet. A side view of the nucleus shows the common pear shape of most solid meteors when in motion. An analysis of this stone by G. Hinrich, gave: Troillite, 1.8, olivine, 52.8; pyroxene, 44.9. A piece in my possession is of a gray color with brown specks,

and very much resembles the Guernsey meteorite. It also has a black crust.

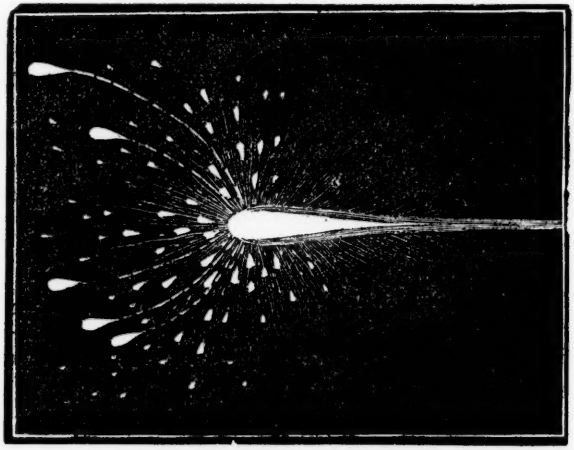


FIGURE 3. Another view of the Iowa Meteor.

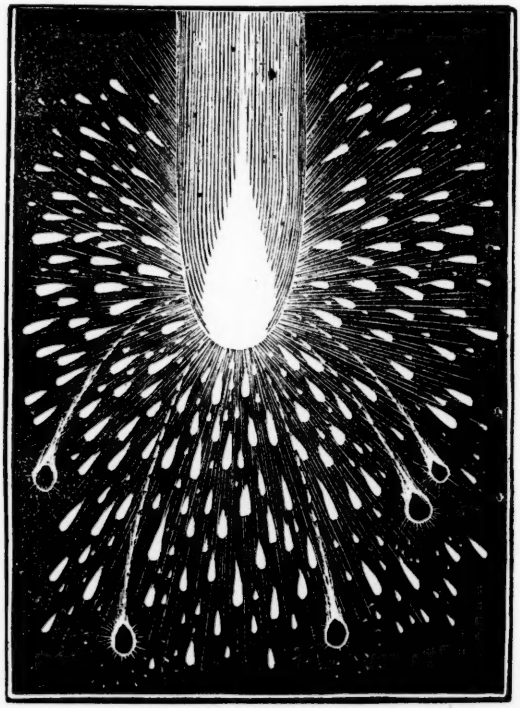


FIGURE 4. Another view of the Iowa Meteor when near the end of its flight.

MISSOURI METEORITES.

It was my good fortune to see one meteor in broad day light, of a clear day, at 9 A. M., September 30, 1865, about half way between Pleasant Hill and Harrisonville, Cass county, Missouri. It appeared in the northwest at an elevation of 30° above the horizon, moving rapidly southwest at about 10° angle with the vertical, emitted sparks and vanished before reaching the Earth.

On the 27th day of December, 1875, about 9 P. M., a brilliant meteor was seen to dart across the northern sky, from West to East, being chiefly observed in Northwest Missouri, illuminating the heavens for a few seconds, brighter than the brightest moonlight, then bursting into fragments. After a few minutes interval, a sound as of distant thunder was heard. The explosion was only heard in Northwest Missouri, although the meteor was seen as far south as Nevada, Vernon county, and Clinton in Henry county. It was seen at Lawrence, Kansas, at Council Bluffs and Iowa City, Iowa; Falls City, Nebraska; at Oregon, St. Joseph, Kansas City, Kirksville, and St. Louis, Missouri; at Cincinnati, Ohio, and Ripley, Indiana.

Mr. William Kaucher of Oregon, Holt county, Missouri, observed it near the Constellation Gemini, passing near Procyon, and beyond, exploding 30° below that star, and 20° above the horizon, in the southeast. Explosions were heard three minutes later.

At St. Jo. it appeared near the zenith, of dazzling brightness, passing eastwardly, exploding and emitting sparks like a rocket, then disappearing. It first appeared red, then blue, then white and bright. Its nucleus appeared one half the size of the Moon, according to one person, while another person thought it about four times the size of the Sun; a fiery sheet, and emitting sparks. About three minutes thereafter a noise was heard, resembling thunder, followed by a deep rumbling noise, continuing for about sixty seconds. At Savanna, Andrew county, it seemed to come from the North-northwest and passed to South southeast, exploding 5° to 12° above the horizon. An explosive sound was heard about three minutes after. At Rockport, Atchison county, it was seen passing southeastwardly. At Pleasant Hill, Cass county, the sky seemed brightly illuminated, and immediately afterwards a bright nucleus or ball of fire with a short tail, appeared in the Northwest, shooting up like a rocket from the horizon towards the zenith, and descending eastwardly. At Clinton, Henry county, Missouri, it passed across the northern sky at 30° elevation, its nucleus appearing twice the diameter of the Sun, with a long luminous tail of a blueish violet color. At Kirksville, Adair county, it was observed 10° to 15° Northwest, at an altitude of 30° to 40°.

Mr. C. W. Irish, of Iowa City, Iowa, observed it at South 60°, West elevation 65°, and thinks that it fell a few miles Southeast of Eagleville in Harrison county. I could hear of no explosion being heard in the counties just south and west, but it was last seen overhead in the southwest part of Linn county.

Many of us saw the very remarkable and brilliant Meteor of December 21, 1876. "It was seen between 8:40 and 9 P. M., from Kansas to Pennsylvania; first appearing nearly over Topeka, Kansas, at an altitude of about sixty miles, thence passing over the centre of North Missouri, exploding several times, crossed the Mississippi between Hannibal and Keokuk, then broke into several pieces, as proved by explosions heard over Central Illinois, between St. Louis and Chicago. The path was nearly parallel to the Earth's surface, and nearly a straight line a 1,000 miles long, occupying as variously estimated, from fifteen seconds to three minutes time. It entered our atmosphere dipping but little from 30° from the Earth's motion, and was overtaking the Earth with a relative slow velocity. It must have been coming from a point in the eastern or southern part of the Constellation Capricornus."* Prof. Daniel Kirkwood, of Bloomington, Indiana, says:† "At 8:45 P. M., a fireball, accompanied by a large number of smaller meteors, was seen in the northern heavens, moving eastward. It appeared 12° to 15° north of west, and 10° above the horizon. Its greatest altitude at Bloomington was 20°, disappearing in the northeast at 5° above the horizon. Its motion was remarkably slow. Many of the smaller meteors appearing about the size of Venus. Some minutes thereafter a rumbling sound was heard. Near Columbus, Ohio, the flock was seen, of forty to sixty, moving as regularly as a flock of geese." It consisted in fact of a large flock of brilliant balls chasing each other across the sky.

At Oregon, Missouri, its apparent size was that of the Moon, passing over the Stellar vault (Mr. Kaucher says) at 8:20 P. M., from near the horizon in the southwest, crossing the meridian at 55° elevation. Light fleecy clouds were seen at this time displaying all the colors of the rainbow.

At Clinton, Missouri, Dr. John H. Britts observed it at 8:20 P. M., in the northwest, at 35° elevation, and passing eastwardly, appearing of a very bright yellow color, and of the size of the full Moon, with a short train which quickly faded away. In the east it seemed to give off several fragments that assued a globular form, and seemed to fall behind and below the main body, disappearing about the same time, each with its own train.

Observers at Pleasant Hill, Missouri, say it emitted sparks just before it disappeared below the horizon, and produced a light greater than moonlight. The only piece seen to fall fell at Rochester, Indiana. Prof. Shepard‖ describes this stone as of a gray color, with a specific gravity of 3 55, rather soft, with a small per cent. of metallic iron.

Prof. J. Lawrence Smith§ describes this stone as of a grayish pisolitic character, very friable, with a dull black coating and composition.

Nickeliferous iron	10.
Troillite	3.
Chrome iron	0.15
Olivine minerals	41.00
Bronzite and pyroxene	46.00
Cobalt—minute traces.	

* H. A. N., in American Journal of Science, Feb. 1877. † American Journal of Science.
‖ American Journal of Science, March, 1877. § American Journal of Science, Sept. 1877.

Warren County Meteorite.—On the morning of January 3d, 1877, just about sunrise, as some wood-choppers were grinding their axes, they heard a rushing sound in the air. Looking up, they beheld something strike the limbs of the trees, dash through them and strike the ground. It seemed to them to come from the northwest, and was of a somewhat conical shape, with a probable weight of about 100 pounds.

I visited the locality about two weeks after, ascertained the locality of the fall to be Sec. 2, T. 46, R. 2, W., or about 4 miles southeast of Warrenton. That the meteor came from the northwest, striking the ground at about an angle of 45°, crushing through the branches of a sugar tree, breaking some limbs an inch in diameter. It seemed to have struck the side of the tree, passing into the frozen ground about 4 inches, one piece flying off about 70 feet to the left; other fragments rebounding about 75 feet in front. It was of a bluish gray color, quite firable, and of rather coarse texture, with a black crust upon the outside nearly a sixteenth of an inch thick.

Dr. J. Lawrence Smith determined the specific gravity to be 3.47, and composition—

Nickeliferous iron	2.01
Olivine minerals	76.00
Bronzite and Pyroxene	18.00
Troillite	3.50
Chrome iron	0.50

Minute traces of Cobalt.

Mr. Irish, of Iowa City, Iowa, informs me that at sunrise on the morning of the 3d there was observed, at an elevation of 60°, and reaching to the horizon, a vivid and prolonged flash of a white light, and wide as the full moon, beginning at a point and widening out as it proceeded. It disappeared in the horizon at about S. 23°, E. true course.

Mr. J. E. Johnston, of Decatur, Ills., saw the same flash at sunrise; a broad, bright track, beginning at 50° to 70° elevation, and running perpendicularly to the horizon. Its vanishing point bore S. 54°, 30° W. magc.

Other less important falls are noted as having taken place in Missouri, but the information concerning them is imperfect.

Dr. B. F. Shumard communicated to the St. Louis Academy of Science, and to the *American Journal of Science*, a notice of a fall having taken place in St. Louis, at 11 A. M. of July 9th, 1862, of a very small meteorite. None of the common minerals found in meteorites were recognised, except iron, hence Dr. S. himself seemed to doubt its being a meteorite.

Between 9 and 10 A. M., June 25, 1876, a small meteorite is stated to have fallen upon the roof of Mr. Isaac Whitaker's house, No. 556 Main street, Kansas City, cutting a hole through the tin, but not passing through it. Mr. J. D. Parker describes it in the *American Journal of Science*, Oct., 1876, as being about one third of an inch in thickness and resembling sulphuret of iron. I have not heard of its being subjected to chemical analysis.

Between half-past 5 and 6 P. M. of Dec. 2d, 1877, a brilliant meteor passed across, from west to east, at probably not over 30° elevation. It was seen at Pleasant Hill and Kansas City.

The WESTERN REVIEW OF SCIENCE chronicles the fall of another meteor on Nov. 29th, at about 6 P. M., that was seen at Kansas City.

Three or four pieces of meteoric iron have been found in different portions of Missouri, of which we possess no record of their time of fall. The largest was obtained by myself, from Bates County, in 1875. It was discovered near Butler. (Lat. 38° 20′ N., Long. 94° 22′ W.) A blacksmith in Butler heated it in order to cut off pieces; one piece of two pounds occupying him about two hours in cutting off. When I obtained the mass it weighed just 85 pounds, probably four or five pounds having been already cut off. Being exposed a long time, it had a thick rusty coat on its surface. The metal is very tough, and shows when cut many nodules of Troillite. I counted fourteen, varying in size from one-eight to an inch, and fifty-eight smaller ones, some mere specks. The Widmanstattian figures were finely developed, and show four systems of lines, of which one system crosses the lines of another at 60°, one at about 78° and one at about right angles. It measures in extreme length ten and a half inches by seven in height, and of irregular shape. An analysis by Dr. J. Lawrence Smith, gave, specific gravity, 7.72. Its composition:

Iron	89.12
Nickel	10.02
Cobalt	.26
Copper	.01
Phosphorus	.12

The troillite has a specific gravity of 4.73.

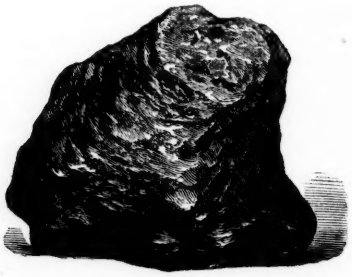


FIGURE 3. Bates County Meteorite, (one-sixth size) from photograph.

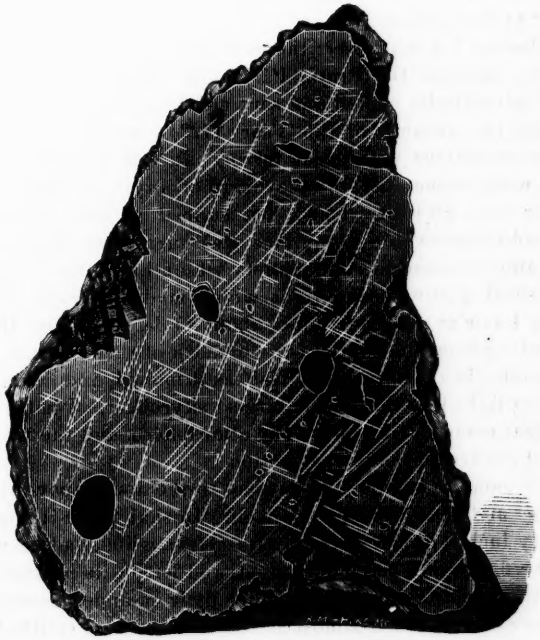


FIGURE 6 Bates County Meteorite, (one-third size) showing polished surface, nodules of Troillite, and Widmanstattian lines, the latter enlarged out of proportion for the sake of distinctness.

Prof. C. U. Shepard, in the *American Journal of Science*, for September, 1860, mentions an iron meteorite from near Forsyth, Taney county, Mo. From Prof. Shepard's description I suppose that it was chiefly composed of iron and nickel, and had a specific gravity of 4.46.

In Prof. C. U. Shepard's catalogue of meteorites, published in the *American Journal of Science and Arts* for May, 1861, we also find No. 57, February 13, 1839, a meteorite from Little Piney, Pulaski county, Mo.

Prof. Daniel Kirkwood catalogues eight bolides between July, 1876, and February, 1877; one of July 8, 1876, at 8:45 P. M., at an altitude of eighty-six miles, passed across Northeast Indiana, bearing N. 78° W., exploding at an elevation of thirty-four miles above Lake Michigan. Its path was inclined 21° to the horizon.

Before closing, I would insert the following extract from the History of Louisiana, by Le Page Du Pratz, Paris, 1758; London Translation, 1774. A friend of mine kindly copied and sent me the account:

"Towards the autumn of this year (1722) I saw a phenomena which struck the superstitious with great terror. It was in effect so extraordinary that I never remember to have heard of anything that either resembled or ever came up to it. I had just supped without doors in order to enjoy the cool of the evening; my face was turned to the west, and I sat before my table to examine some planets which had already appeared.

"I perceived a glimmering light which made me raise my eyes, and immediately I saw at the elevation of about 45 degrees above the horizon a light proceeding from the south of the breadth of three inches, which went off to the north, always spreading itself as it moved, and made itself heard by a whizzing light like that of the largest skyrocket. I judged by the eye that this light could not be above our atmosphere, and the whizzing noise that I heard confirmed me in that notion."

"When it came to be about 45 degrees to the north above the horizon it stopped short and ceased enlarging itself. In that place it appeared to be about twenty inches broad, so that in its course, which had been very rapid, it formed the figure of a marine trumpet, and left in its passage very lively sparks, shining brighter than those which fly from under a smith's hammer; but they were extinguished almost as fast as they were emitted."

"At the north elevation there issued out with a great noise from the middle of the large end a ball quite round, and all on fire apparently, six inches in diameter. It fell below the horizon to the north and emitted about twenty minutes after a hollow but very loud noise for the space of a minute, which appeared to come from a great distance. The light began to be weakened to the south, after emitting the ball, and at length disappeared before the noise was heard."

GEOGRAPHICAL.

PLAN FOR THE EXPLORATION OF THE ARCTIC.*

FURNISHED BY CAPT. H. W. HOWGATE, U. S. A.

The plan of Arctic Exploration and Discovery, in furtherance of which I have the honor of appearing before you this evening, is one to establish a colony of hardy, resolute and intelligent men at some favorable point on or near the borders of the Polar Sea and providing it with all modern appliances for overcoming the physical obstables in the pathway to the Pole, and for resisting the effects of hunger, of cold, and of sickness, to deprive it of the means of retreat, except at stated periods of time. The location selected as the site of the proposed colony is on the shore of Lady Franklin Bay, near the seam of coal found by the "Discovery," of the English expedition of 1875.

The idea of establishing such a colony is not a new one, as it was advocated by Dr. Hayes as far back as 1862, and has since that date been approved by this society and by the action of foreign societies and explorers. This fact accounts, in great part, for the almost unanimous support with which the so-called Howgate plan has been received.

The results of the last English expedition, and modern improvements in means of locomotion and communication, render it possible to locate farther north than in the earlier days of Arctic exploration, when sailing vessels were used.

The expedition of Captain Hall in the Polaris, in 1871, and of Captain Nares in the Alert and Discovery, in 1875, have shown that, by the use of steam, it is a comparatively easy matter to reach the entrance to Robeson's Channel in latitude 81° north, and that the serious difficulties to be overcome lie beyond that point. Parties from these two expeditions have made fair surveys 140 miles north of this point, leaving about 400 miles of unexplored regions between it and the goal of modern geographers—the Pole.

When Captain Hall reached the upper extremity of Robeson's Channel the lookout of the Polaris reported open water in sight and just beyond the pack which surrounded the vessel and impeded further progress. This open water was afterwards seen from the cape at the northern opening of Newman's Bay, and it was the opinion of the crew of that ill-fated vessel, that if she had been but the fraction of an hour earlier in reaching the channel, they could have steamed unobstructed to the Pole itself, or to the shores of such lands, if any exist, as may bound the so-called open Polar Sea. We know that they did not succeed, but were forced to winter almost within sight of this sea, and subsequently, disheartened by the loss of their gallant commander, abandoned the enterprise.

* A paper prepared by Capt. Howgate, and read at the meeting of the American Geographical Society in New York, January 31, 1878.

Where this open water was found, Captain Nares, in 1875 and 1876, found solid, impenetrable ice, through which no vessel could force its way, and over which it was equally impossible for sled parties to work.

These facts appear to show that, within the Arctic circle the seasons vary as markedly as in more temperate southern latitudes, and that the icy barriers to the Pole are sometimes broken up by favoring winds and temperature. To get further north, or to reach the Pole, prompt advantage must be taken of such favoring circumstances, and to do this with the greatest certainty and with the least expenditure of time, money, and human life, it is essential that the exploring party be on the ground at the very time the ice gives way and opens the gateway to the long-sought prize, fully prepared to improve every opportunity that offers.

The permanent colony should be furnished with provisions and other necessary supplies for three years, and should consist of at least fifty selected men, mustered into the service of the United States, three commissioned officers, and two surgeons, all to be selected with a view to their especial fitness for the work—young, able-bodied, resolute men, who can be depended upon to carry out instructions to the extreme limit of human endurance. An astronomer and two or more naturalists, to be selected by the National Academy of Sciences, and to work under instructions from that body, but subject to such general supervision and directions from the head of the expedition as is customary at all posts in charge of an officer of the United States, should accompany the expedition. One or more members of the regular force should be competent to make meteorological observations, and to communicate by telegraph and signals whenever such communications become necessary. An annual visit should be made to the colony to carry fresh food and supplies; to keep the members informed of events occurriug in the outside world, and bear them news and letters from anxious relatives; to bring back news of progress made and of a private character to friends; also, if necessary, to bring back invalided members of the expedition, and carry out fresh colonists to take their places. In this way the morale of the colony would be maintained and the physique of its members kept constantly at the maximum, and the knowledge that this annual visit would be made, would do much to alleviate the discomforts of the long Arctic night, and the feeling of isolation so graphically described by Arctic explorers.

Captain Hall spent eight years among the Esquimaux, and each year found himself better fitted to withstand the severity of the Arctic circle, and the colony would, it is believed, in like manner become acclimated, and eventually succeed in accomplishing the long-sought end.

With a few strong, substantial buildings, such as can be easily carried on shipboard, the members of the colony could be made as comfortable and as safe from atmospheric dangers as are the men of the Signal Service, stationed on the summits of Pike's Peak and Mount Washington, or the employès of the Hudson's Bay Company, stationed at Fort York, or elsewhere, where a temperature of—60° is not uncommon.

A good supply of medicines, a skillful surgeon, and such fresh provisions as could be found by hunting parties would enable them to keep off scurvy and maintain as good a sanitary condition as the inhabitants of Godhaven, in Greenland. Game was found in fair quantities by the Polaris party on the Greenland coast, and by those from the Alert and Discovery, on the mainland to the west, especially in the vicinity of the last-named vessel, where fifty-four musk-oxen were killed during the season, with quantities of other and smaller game. The coal found by the Discovery's party would render the question of fuel a light one, and thus remove one of the greatest difficulties hitherto encountered by Arctic voyagers.

There seems to be little doubt that Lady Franklin Bay can be annually reached by a steam-vessel, as Capt. Hall went as high as Cape Union, between latitude 82° and 83° with the Polaris, and Capt. Nares still higher with the Alert. It is possible that the last-named point may be reached with the vessel, in which case coal and provisions could be deposited there to form a secondary base of operations for the exploring party. If this latter can be done, the road to the Pole will be shortened by about ninety miles in distance, and three weeks or more, in time—two very important items. It should be clearly understood, that the only use to be made of the vessel which it is hoped to obtain from the Government, is in the transportation of the men and supplies to the location of the colony. When this is done, the vessel will return to the United States and await further instructions. To the expeditionary corps brought from the United States should be added a number of Esquimaux families to serve as hunters, guides, &c., and also an ample number of Esquimaux dogs, so indispensable for sledging, and so useful as food when their capacity for work is gone.

The colony should be kept under the strictest discipline, and to this end should be formally enrolled in the military service, save perhaps the strictly scientific members. By discipline only can such control be exercised as will be indispensable to the successful prosecution of the work. One cannot read, without pain, the account of the Polaris expedition, where the bonds of discipline, only too loose before Hall's untimely death, were entirely relaxed after it. The first in command of the new expedition should be a man able not only to gauge men, but to control them, and his second should be like unto him. Enthusiasm and energy are desirable, but coolness of temper, firmness of rule, persistency of purpose, and a well-balanced mind, fertile in resources and expedients, are indispensable to success.

The outfit of the expedition should include among other things, an ample supply of copper telegraph wire to connect the colony at Lady Franklin Bay with the subsidiary depot at Cape Union, and thence northward, as far as practicable. Copper wire is strong, light, flexible, and a good conductor, and can be worked while lying upon the dry snow or ice without support. The necessary battery material and instruments should be taken to equip the line, and the battery left permanently at the bay station, where, fuel being abundant, it could be kept from freezing. A special

form of instrument has been devised for the expedition, by which the use of battery is dispensed with entirely, and it is possible that the recently-discovered telephone may be applied to advantage. It should certainly form a part of the outfit. Much attention has been given to the possible use of balloons as a means of observation and perhaps of exploration. I am now in correspondence with distinguished aeronauts in this country and in France upon the subject, and a series of experiments has been instituted to determine the practicability of obtaining a suitable material for the covering of the balloons that will resist low temperature. Here, as elsewhere, the coal mine plays an important part, as by its aid the necessary supply of gas can be readily and quickly procured.

A few sets of signal equipments, such as are used in the army Signal Service, would also form an important part of the outfit, and all of the men should be instructed in their use, and in the Signal code. Thus provided with means of communication, parties could move forward with confidence, as they would be able, when necessary, to call upon their comrades, who remained behind, for advice or assistance. The existence of coal at the "Discovery's" winter quarters determines the question of colonization and the location of the colony as a means of Polar exploration; and the Nares expedition would have been a success if it had done nothing more than this. The failure of his admirably equipped expedition to reach the Pole is, in a great measure, attributable to the abnormally cold season and the exceptional character of the winds, which had resulted in the formation of ice ridges running across the line of march, thus making progress difficult, slow and dangerous. It is reasonable to suppose, from past meteorological records, that these unusual conditions will not exist during the present season, and indeed may not occur again for several years. Instead of discouraging further effort, the result of Nares' expedition, from the causes named, should stimulate fresh endeavors, and hold out a fair prospect of success. In any event, the little colony on Lady Franklin Bay during their three years' residence, besides having the opportunity of selecting an open season and becoming thoroughly hardened and acclimated, would have their work narrowed down to a common focus—the path-way due north. The work of the Nares expedition clears the way for the final solution of the Arctic problem.

To carry out the plan thus briefly sketched, it is desirable to secure the use of a government vessel, and, inasmuch as its object is one of national interest, such other Government aid as might be necessary and proper; and accordingly, a bill to "authorize and equip an Expedition to the Arctic Seas" was introduced in the House of Representatives January 8th, 1877, by Mr. Hunter, of Indiana, and referred to the Committee on Naval Affairs, from which it was favorably reported by Mr. Willis, of that committee, February 22nd, 1877. In the Senate the same bill was introduced by Mr. Dawes, and referred to the Committee on Naval Affairs, February 9th, 1877. The pressure of other and more important business then occupying the attention of Congress and of the nation, prevented further action during the session,

which closed on the 3rd of March last. The subject was found, however, to be one of national and universal interest, and received the hearty commendation and support of former Arctic explorers, of geographers, and of men eminent in the several walks of science, among whom I may name the distinguished President of this Society and the Hon. I. I. Hayes, both of whom have from the first given me their warmest encouragement and the benefit of their wide experience. Professor Joseph Henry, of the Smithsonian Institute, Professor Elias Loomis, of Yale College, President Potter, of Union College, Admiral Porter, of the Navy, the then Secretary of the Navy, and most of the officers and crew of the *Polaris*, with many others, have given the weight of their names and influence in support of the enterprise in this country, while abroad I have abundant evidence of interest from members of former expeditions, notable among whom are Dr. John Rea and Captain Kennedy, of English fame, and Lieutenant Payer, of the Austro-Hungarian Expedition.

As practical evidence of the interest felt in the subject in this country, a number of public spirited and generous citizens, among whom, it is a pleasure to state, those of this city occupy the foremost place, having faith in the success of the colonization plan as a means of Arctic exploration, and believing in its ultimate approval by Congress, contributed from their private means a sufficient sum for the purchase and outfit of a small vessel to be sent to the Arctic seas for the purpose of collecting such supplies during the ensuing winter as might be useful for the main expedition of 1878, if that expedition should be authorized. It was at first intended to limit the mission of this vessel to the collection of material only, but the opportunity for scientific investigation was so inviting, and the added cost incurred thereby so very trifling in comparison with the results to be attained, that space was made on board for two observers and their necessary apparatus. One of these observers was selected on the recommendation of Professor Elias Loomis, of Yale College, and instructed to pay especial attention to meteorological phenomena, while the other was selected as naturalist of the expedition by Professor Spencer F. Baird, of the Smithsonian Institute, from whom he received special instructions.

This vessel, the *Florence*, sailed from New London August 3d, with a crew of thirteen men, all told, commanded by Capt. Tyson, of "Polaris" fame, and reached the head of Cumberland Gulf on September 13th, where she has gone into winter quarters. Captain Tyson's instructions are to collect such supplies as his experience shows to be necessary for the use of the future colony, and to join the vessel carrying the members of the colony at Disco in August next, and in the event of its non-arrival, to return to the United States.

There is reason to hope, from the knowledge and attainments of the two scientific gentlemen accompanying the *Florence*, that the little vessel will, on her return, add no small quota to our knowledge of Arctic cosmogony and phenomena. But however that may be, her loss or safety must remain a closed book to us for many months to come. What perils she may meet,

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what dangers dare, what obstacles overcome, we can neither know nor forecast, but she and her gallant crew are none the less in the hands of Him who rules the ice-bound waste as surely as He rules this crowded city, and without whose paternal knowledge not even the sparrow falls.

To guard against possible delay, in the event of Capt. Tyson's failure to reach Disco at the proper time or without proper supplies, the Danish Government has been requested to delay the shipment of furs from that point until the middle of August, in order that a supply may be purchased from that source if necessary.

As soon after the opening of the present session of Congress as practicable, the bill to authorize the expedition was offered in the Senate and House of Representatives, and in both referred to the Naval Committee. The House Committee, through Mr. Willis, of New York, who from the first has been an active friend of this measure, has renewed its favorable report of last session, and the bill is now awaiting the final action of the House upon it. From the Senate Committee I have the assurance of a favorable report. Senators Sargent and McPherson, having immediate charge of the bill, have exhibited a gratifying interest in its success, and it is reasonable to hope for its final passage.

In Paris, M. de Fonvielle, who is well known as an accomplished aeronaut and man of letters, is making a series of balloon experiments for the benefit of the future colony, in the foundation of which he takes a lively interest, and the French Geographical Society, at its last regular session, formally expressed its approval of the plan. The Bremen Geographical Society, through its Secretary, Dr. Lindeman, had previously expressed a similar approval, and everything seems working favorably toward the accomplishment of the desired end; even the mighty forces of nature and the changeful seasons appear to labor for the success of the expedition; for the present winter, of such unprecedented mildness, will undoubtedly retard the formation of ice in the Polar basin, and leave a freer passage for the colony next summer, up Baffin's Bay to Kennedy and Robeson's Channels. The great veteran explorer, Professor Nordenskiold, and the favorable reports which he brings back with his expedition just returned, with the wonderful voyage of Captain Wiggins from the mouth of the Yenessei along the Siberian coast and through the Kara Sea, all demonstrate that the open season has unsealed the ice of higher latitudes, and points to a favorable northward passage during the coming summer.

I have not touched this evening upon the vast interests to science which Polar expeditions represent, and the important questions which they alone can solve, nor upon the geographical theories and arguments in support of the different routes that might be followed, preferring to leave the settlement of these subjects to more competent hands. The noble Earl who honors us with his presence this evening, and who has won distinction in Arctic fields as well as in those of statesmanship, and Dr. Hayes, whose triumphs as an explorer have been supplemented by those accorded to the successful

legislator, can tell us with the graphic tongue of eyewitnesses, the wonders of the strange lands we seek to colonize, and whose hidden secrets we seek to solve; for both have watched the colossal or fairy shapes of mountainous icebergs with their changeful play of hues under the midnight sun, or the mighty arch of the aurora, with its trailing fringes of incandescent colors spanning through the long night of Arctic winter, the mystic sea of ice and silence. Their presence, and that of the other distinguished gentlemen who are announced to address us, and whose names are as familiar as household words wherever the English language is known or spoken, I hail as an augury of success, and I heartily join with them and you in doing honor to the name and achievements of our countryman Stanley, in penetrating the wilds of Africa. There is no city throughout the whole broad Union more suitable for such a meeting as the present, a city where the memory of Grinnell, the great and public-spirited merchant, is still green, and where so many others, their hearts as generous as their means were large, have given freely of their store to aid in Arctic discovery and in whatever else was good and noble in art and science, in love and charity.

In closing, permit me at present to thank you all for your attention and your kindly manifestation of interest in the subject, and to hope that such action will be taken by Congress as will invest it with added interest in the near future.

CHEMISTRY.

LIQUEFACTION OF OXYGEN.

BY M. RAOUL PICTET.

The object which I have had in view for more than three years is to demonstrate experimentally that molecular cohesion is a general property of bodies, to which there is no exception.

If the permanent gases are not capable of liquefying, we must conclude that their constituent particles do not attract each other, and thus do not conform to this law.

Thus, to cause experimentally the molecules of a gas to approach each other as much as possible, certain indispensable conditions are necessary, which may be expressed thus:—

1. To have the gas absolutely pure, with no trace of foreign gas.
2. To be able to obtain extremely energetic pressures.
3. To obtain intense cold, and to subtract heat at these low temperatures.
4. To utilize a large surface for condensation at these low temperatures.
5. To be able to utilize the rapid expansion of the gas from extreme condensation to the atmosphere pressure—an expansion which, added to the preceding means, will compel liquefaction.

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Having fulfilled these five conditions, we may formulate the following alternative :—

When a gas is compressed to 500 or 600 atmospheres, and kept at a temperature of −100° or −140°, and it is allowed to expand to the atmospheric pressure, one of two things takes place :—

Either the gas, obeying the force of cohesion, liquefies, and yields its heat of condensation to the portion of gas which expands and loses itself in the gaseous form ; or, on the hypothesis that cohesion is not a general law, the gas must pass to the absolute zero and become inert—that is to say, an impalpable powder.

The work done by expansion will not be possible, and the loss of heat will be absolute.

Struck with the truth of this alternative, which is rendered certain by thermo dynamic equations based on accurate data, I have sought to produce a mechanical arrangement which should entirely satisfy these different conditions, and I have chosen the complicated apparatus of which the following is a brief description :—

I take two pumps for exhaustion and compression, such as are used industrially in my ice making apparatus. I couple these pumps in such a way that the exhaustion of one corresponds to the compression of the other. The exhaustion of t e first communicates with a tube of 1.1 metres long and 12 5 centimetres in diameter, and filled with liquid sulphurous acid. Under the influence of a good vacuum the temperature of this liquid rapidly sinks to −65°, and even to −73°, the extreme limit attained.

Through this tube of sulphurous acid passes a second smaller tube of 6 centimetres in diameter, and the same length as the envelope. These two tubes are closed by a common base.

In the central tube is retained compressed carbonic acid produced by the reaction of hydrochloric acid on Carrara marble. This gas, being dried, is stored in an oil gasometer of 1 cubic metre capacity.

At a pressure of from 4 to 6 atmospheres the carbonic acid easily liquefies under these circumstances. The resulting liquid is led into a long copper tube 4 metres in length and 4 centimetres in diameter.

Two pumps, coupled together like the first, exhaust carbonic acid either from the gasometer or from the long tube full of liquid carbonic acid.

The ingress to these pumps is governed by a three-way tap. A screw valve cuts off at will the ingress of liquid carbonic acid in the long tube ; it is situated between the condenser of carbonic acid and this long tube. When this screw valve is closed, and the two pumps draw the vapor from the liquid carbonic acid contained in the tube 4 metres long, the greatest possible lowering of temperature is produced ; the carbonic acid solidifies and descends to about −140°. The subtraction of heat is maintained by the working of the pumps, the cylinders of which take out 3 litres per stroke, and the speed is 100 revolutions a minute.

Both the sulphurous acid tube and the carbonic acid tube are covered with a casing of wood and non-conducting stuff to intercept radiation.

In the interior of the carbonic acid tube passes a fourth tube, intended for the compression of oxygen; it is 5 metres long and 14 millimetres in external diameter. Its internal diameter is 4 millimetres. This long tube is consequently immersed in solid carbonic acid, and its whole surface is brought to the lowest obtainable temperature. These two long tubes are connected by the ends of the carbonic acid tube, consequently the small tube extends about 1 metre beyond the other. I have curved this portion downward and given the two long tubes a slightly inclined position, but still very near the horizontal.

The small central tube is curved and screws into the neck of a large howitzer shell, the sides of which are 35 millimetres thick; the height is 28 centimetres, and the diameter 17 centimetres.

This shell contains 700 grms. of chlorate of potash and 256 grms. of chloride of potassium mixed together, fused, then broken up, and introduced into the shell perfectly dry. When the double circulation of the sulphurous and carbonic acids has lowered the temperature to the required degree, I heat the shell over a series of gas burners. The decomposition of the chlorate of potash takes place at first gradually, then rather suddenly towards the end of the operation. A pressure-gauge at the extremity of the long tube, lets me constantly observe the pressure and the progress of the reaction. This gauge is graduated to 850 atmospheres, and was made for me expressly by Bourdon, of Paris.

When the reaction is terminated the pressure exceeds 500 atmospheres; but it almost immediately sinks a little, and stops at 320 atmospheres. If, at this moment, I open the screw-tap which terminates the tube, a jet of liquid is distinctly seen to spirt out with extreme violence. I close the tap, and in the course of a few moments a second jet—less abundant, however—can be obtained.

Pieces of charcoal, slightly incandescent, put in this jet inflame spontaneously with inconceivable violence. I have not yet succeeded in collecting the liquid, on account of the considerable projectile force with which it escapes, but I am trying to arrange a pipette, previously cooled, which possibly may be able to retain a little of this liquid.

Yesterday I repeated this experiment before the majority of the members of our Physical Society, and we had three successive jets, well characterized. I cannot yet determine the minimum pressure necessary, for it is evident that I have a surplus pressure produced by the excess of gas accumulated in the shell, and which could not condense in the small space represented by the interior tube.

I hope to utilize a similar arrangement in attempting the condensation of hydrogen and nitrogen, and I am especially occupied with the possibility of maintaining low temperature very easily, thanks to four large industrial pumps which I have at my disposal, worked by a steam engine.

GENEVA, DECEMBER 25, 1877.

Since receiving the above we have been favored with further particulars

of an experiment which was performed for the fourth time on Thursday, December 27th, in the presence of ten scientific men—among others Prof. Hagenbach, of Bâle, who came expressly to assist at this important experiment.

At 10 o'clock in the evening the manometer, which had risen to 560 atmospheres, sank in a few minutes to 505, and remained stationary at this figure for more than half an hour, showing by this diminution in the pressure that part of the gas had assumed the liquid form under the influence of the 140 degrees of cold to which it was exposed. The tap closing the orifice of the tube was then opened, and a jet of oxygen spirted out with extraordinary violence.

A ray of electric light being thrown on the escaping jet showed that it was chiefly composed of two parts;—one central, and some centimetres long, the whiteness of which showed that the element was liquid, or even solid; the other exterior, the blue tint of which indicated the presence of oxygen compressed and frozen in the gaseous state.

The success of this remarkable and conclusive experiment called forth the applause of all present.

We understand that Messrs. Pictet & Co., of 22, Rue de Grammont, Paris, are fitting up apparatus with the intention of having these experiments repeated at their Freezing-Machine Works, at Clichy, in Paris.—*London Chemical News.*

LIQUEFACTION OF NITROGEN, HYDROGEN AND ATMOSPHERIC AIR.

M. Cailletet has comunicated to the *Academie des Sciences* some further particulars on the liquefaction of gases, and at the meeting of the 31st of December a paper was read, from which we translate the following:

"*Nitrogen.*—Pure and dry nitrogen compressed to about 200 atmospheres, at a temperature of +13°, then allowed to expand suddenly, condenses in the most perfect manner; it first produces an appearance like that of a pulverized liquid in small drops of appreciable volume; this liquid then gradually disappears from the sides to the centre of the tube, at last forming a sort of vertical column following the axis of the tube. The duration of these phenomena is about 3 seconds.

"These appearances leave no doubt as to the true character of the phenomena. I first tried the experiment at home at a temperature of —29°, and I repeated it yesterday, the 30th of December, several times at the Laboratory of the Ecole Normale, in the presence of many savants and members of the Academy, among whom I am happy to name, with his assent, the venerable M. Boussingault.

"*Hydrogen.*—Hydrogen has always been considered the most incondensable gas, on account of its low density, and the almost complete agreement of its mechanical properties with those of perfect gases. Thus it was only

with great doubt as to the result that I decided to submit it to the same tests which had determined the liquefaction of all the other gases.

"In my first attempt I noticed nothing particular, but, as often happens in experimental science, skill in observing phenomena results in causing signs to be recognized under conditions where they had at first escaped notice.

"This is what occurred with hydrogen: On repeating my experiments to-day, in the presence of MM. Berthelot, H. Sainte-Claire Deville and Mascart, who have allowed me to quote their testimony, I have succeeded in observing indications of the liquefaction of hydrogen under conditions of proof which have left no doubt on the minds of the scientific men who witnessed the experiment. It has been repeated a great number of times. Operating with pure hydrogen compressed to about 280 atmospheres, and then allowed suddenly to expand, we saw form an extremely attenuated and subtle mist suspended in the gas and disappearing suddenly. The production of this mist, in spite of its extreme subtlety, seemed incontestable to all the scientific men who witnessed the experiment to-day, and who took care to have it repeated several times, so as to leave no doubt as to its reality.

"*Air.*—Having liquefied nitrogen and oxygen, the liquefaction of air is thereby demonstrated. It appears, however of interest to make this the subject of an actual experiment, and, as might be expected, it succeeded perfectly. I need not say that the air was previously dried and freed from carbonic acid. The accuracy of the views expressed by the founder of modern chemistry, Lavoisier, is thus confirmed as to the possibility of causing air to assume the liquid state, and of producing matter gifted with new and unknown properties—views recalled so appropriately at the last meeting of our illustrious perpetual secretary."—*London Chemical News.*

A NEW METHOD OF ILLUMINATING A TOWN

BY PROF. E. L. BERTHOUD, COLORADO SCHOOL OF MINES.

In 1874-75 I was examining the question of the lighting of a small town in Eastern Colorado, and the cheapest and easiest method attainable. I went over the usual routine of gas, petroleum, and all of the so-called cheap gases and gas processes.

Happening to know that the Foreland Light-house in England was illuminated by an electric light, I obtained some data from England in regard to this method, which, successful, has been in use many years, but being originally and then kept up by a large battery, was expensive and rather complicated. Since 1874 however, Mr. Gramme, in France, has invented and patented an easy and cheap method of obtaining a constant flow of electricity by an electrical frictional machine of great power and constancy much superior in cheapness and in constancy to the combination of Daniells

or Bunsen's electro-magnetic batteries, of which it would require from 100 to 150 couples to get an electric flow of sufficient power and constancy. Having satisfied myself of the feasibility of using this method of illumination, the next point was to adapt it to our mountain village.

To my surprise I found all the conditions for a successful illumination were easily within reach—half a mile from the centre of the town, and east of it is a high, steep table land, crowned by a castellated crag some 600 feet immediately above the village. Here I propose to place the electrical machine, and the electric light in a glass and iron tower, fifteen feet high, placed on the edge of the crag and immediately overlooking the streets. Placed in a semi-circle before the light will be five Fresnel lenses, each of which will concentrate its rays upon a separate district of the town, or five concave specula; either would answer the desired purpose, and all points in the streets and alleys parallel with the rays from the several lenses or reflectors would be brightly illuminated, while the streets crosswise to the rays would have a shadow side. This shadow side I propose to illuminate by having every 150 feet a lamp-post on the illuminated side provided with a reflector, which would thus throw a bright light across the street and prevent any undue darkening of one side in the shadow of the dwellings.

Another use is suggested for the electric light. In every house or room which presented its end or side towards the electric light, I propose to insert in a hole in the side or end a large glass prism which would reflect the light inside, and thus illuminate the inside of the room brilliantly and intensely, and without the concomitant of fire, explosive petroleum or dirty candles; requiring nothing to keep it in order but a clean cloth or piece of buckskin to wipe it; and which would be readily extinguished by a sliding shutter over the aperture. If preferred, the prism can be placed on the roof, and the rays reflected from above inside, as in a church or large hall; or even in a second story school or lecture room. If to some, the intense brightness of an electric flame is too much for their eyesight, then variously colored prisms can be used to modify the intense light into pleasing softness. We could thus use blue, green, yellow, brown or opal colored prims, shaded to the exact requirements of an artisan's workshop, or to the taste and optical weakness of individual eyesight. An electric light equal in intensity to 350 candles, would, in Colorado, cost 30 cents per hour.

GOLDEN, COL., January 26, 1878.

EASY LESSONS IN CHEMISTRY.—The following names from a recent German journal of chemistry will be good practice in spelling and reading for juvenile students of the science: Methylcarbominthioglycolic acid; dinitribromdiphenylamin; oxaldiphenylguanidin; parabrommetasulphophenylpropionic acid; parapicrylmetanitralin; ethoxilphenilpropyformiate of paratoluilendiamin; methylethylpropylamylammonium oxide hydrate.

FOREIGN CORRESPONDENCE.

PARIS, FRANCE, Jan'y 22, 1878.

There is a decided taste for hygienic studies, and, what is not less important, of applying their lessons. The science of hygiene is not intended to supersede doctors, but to increase the well-being of peoples and of individuals, by augmenting the robustness of their bodies, and consequently the strength of their minds. The role of hygienists is not altogether confined to preserving us from maladies, for there are several very terrible diseases that we are powerless to counteract; still, before destroying the germs of maladies it is prudent on the part of man to endeavor to resist them with success. Moses and Mahomet deserve special honor for the accuracy with which they formulated sanitary rules for public and private life of Oriental people. Perhaps it would be well in the case of Islamism that the verses of the Koran were applied more frequently than they are repeated. The pagan societies of Greece and Rome have leagued us many important hygienic precepts: in the amplitude of their clothing, which left to the articulations and muscles all their suppleness and liberty of action, and in their ablutions, which acted as a tonic for the skin and imparted a general impulsion to the organic functions. The love of the ancients for gymnastic and other corporeal exercises is proverbial, and in their considering Prometheus as the first gymnast, in addition to viewing him as the creator of men, it was merely implied that he developed and renewed life by inculcating the importance of physical exercise. Dr. LeBlond not only advocates but prescribes gymnastics as a curative agent, and the means best calculated to develop the physique of each individual, following sex, age, temperament and profession; to produce in a word, "the soul of a sage in the body of an athlete."

Since the municipality of Paris has fallen asleep over the proposed metropolitan cemetery, the project of cremation is making rapid progress. Opinion is certainly on the point of reclaiming, that a family be allowed the right to incinerate or inhume its dead. The practice of the Middle Ages, in burying the dead beneath the flags of an aisle, is not a whit more insalubrious than interments in church yards in the midst of the living. In 1760, Voltaire complained that "there was not a defunct who did not, more or less, contribute to poison his country." Citizens do not follow that philosopher in his rapture of the pleasure it would be for his fellow-countrymen "to enrich some of the sterile plains of France, and so contribute to abundant harvests; generations would thus become more useful to each other; the towns more healthy, and the fields more fruitful."

Professor Valin continues to demonstrate the necessity of isolation of the sick, as the most effectual plan for checking the propagation of contagious

maladies. "Pen the disease, make a void round it, capture it by famine." The most effectual method for counteracting croup, whether in hospitals or families, is isolation. In the case of diphtheria, this plan is adopted in French hospitals, and with great success.

Matter presents itself under three forms: solid, liquid and gaseous. A gas operated upon, under certain conditions, will become a liquid, and the liquid solid. Ice can be changed into water, water into vapor. This rule ought to be general; they are the energetic means alone which are wanting. Faraday liquefied several permanent gases by means of a freezing mixture composed of solid carbonic acid; but several gases, such as oxygen, hydrogen, nitrogen, oxide of carbon and bi-oxide of nitrogen resisted all his experiments. M. Cailletet, a distinguished chemist, has succeeded in liquefying bi-oxide of nitrogen by a new process. In a gas, the constituent atoms are wide apart; in a liquid, not so much; and least of all, in a solid. To liquefy a gas the atoms must be brought nearer to each other, then compressed, and next congealed. Cold is the most energetic of these reducing agents. After compressing a gas by means of a hydraulic pump, M. Cailletet liquefied it afterwards with the ordinary freezing mixtures. When the pressure is suddenly removed, the gas expands, and as is well known, the act of expansion produces a diminished temperature. The experimenter has demonstrated, what others have suspected, that there is a "critical point" of temperature, above which no gas can be liquefied. The practical applications of the beautiful discovery made by M. Cailletet can be immense. He has liquefied carburet of hydrogen, consisting of two elements, carbon and hydrogen. Now if he could obtain the carbon in a crystallized form, that would be the diamond.

M. de Chancourtois, an eminent engineer, lately asked if the diamond was not produced by a reaction, similar to that which engenders sulphur in certain localities where sulphuretted hydrogen, escaping from the fissures, the hydrogen unites with the oxygen of the air and forms water, the sulphur being deposited in the state of crystal. Replace the sulphurous by emanations of carbon, and the latter may be also deposited in a crystallized form. Where diamonds are most found, is exactly in that geological period—the Devonian, remarkable for bituminous impregnations, thus marking the intensity of carbon emanations. This negative solution in favor of the manufacture of diamonds is valuable.

So great is the inattention to the proper fitting up of school-rooms, that the wonder is, so many persons escape being hunchbacked or shortsighted. The seats and desks are generally of a uniform pattern for large as for small boys, deforming thus the vertebral column, and the lighting is so defective that 22 per cent. of the pupils, of French primary schools especially, are shortsighted, and this affliction becomes more pronounced the longer lads remain at school, that is to say, pass to the secondary schools or colleges.

Messrs. Trèlat and Gariel advocate that school-rooms should be lighted "bilaterally," not from the centre, and thus flood the eye completely with light —incompleteness in this respect producing nearsightedness. Michelet, though poetically, has not the less accurately observed; the eye is a human flower, which has want of sun-light, as other flowers, to prevent etiolation and languishing. M. Dally, on the subject of the physiological aspects of education, asks, Are we right to have a common dietary for children of the establishment, when some of them have a predisposition for certain diseases that an appropriate regimen could prevent? He also disapproves of those systems of education, which replace, at the commencement of the child's cerebral life, impressions, sensations and object lessons for the abstractions of grammar, dead languages, &c.

The influence of colored light on plants and animals has lately occupied much atteution. It is difficalt at first to comprehend how the action of light can affect an invalid. M. Fano states that he has completely cured persistent headache by his patient employing yellow glass spectacles. The afflicted on attempting to read or write only augmented the headache, yet as some kinds of intellectual work did not produce fatigue, M. Fano concluded that the pain arose from the action of the retina on a morbid state of the nervous centres. He decided to change the conditions of perception for the retina, by no longer exciting it by the ordinary rays; he employed glass to produce only yellow rays; the pain diminished, and by continuing the same glasses, ultimately disappeared. M. Fano also obtained satisfactory results in certain cases, by the use of red, violet and other colored glass one person being sensible to blue, another to rose, following constitution. There are harmonies which delight the ear, why not colors to charm the eye, and calm also its nervous system?

Science, in point of novelties, keeps up with the spirit of the age. We have had hygrometric or barometric flowers, which changed color, following the humidity or dryness of the air; at present we have luminous flowers, that it suffices only to expose to the sun, to observe them afterwards becoming phosphorescent in obscurity. The flowers are prepared with sulphurets of calcium, strontium, &c., compounds known as artificial phosphorus. Messrs. Dagron and Giselon have produced "sympathetic pipes." They can "color" a meerschaum the most beautiful chocolate in five minutes by tinting the bowl with a solution of ether and alcohol, to which essence of roses, camphor, nitrate of silver, &c., are joined, so that any image or superscription painted on the pipe will gradually come out, like the impression of a photograph, under the influence of the light or the heat of the pipe. You can have your own portrait, or that of a friend, your dog or horse sketched on the pipe, as the likeness will appear on exposure to the air. It is well to remember, the metamorphosis once accomplished, is permanent.

Lavoisier demonstrated that a diamond consisted only of carbon, by

changing it into carbonic acid. Messrs. Fremy and Feil are more commercially happy, in producing rubies, sapphires and corundums, which, like amethyst, emery and adamantine spar, are but varieties of alumina. Artificial rubies had been previously prepared, but only in the form of something like dust; albite and other varieties of feldspar have also been artificially prepared. The processes consist in subjecting a mixture of alumina, an alkali, an acid and a coloring matter to an intense heat during three weeks. This great temperature is but a tiny sample, at best, of that gigantic furnace—the earth's central heat, which melts, solders and petrifies rocks, to project through fissures to the surface. Is the discovery of Messrs. Fremy and Feil the philosopher's stone? They have produced specimens of rubies and sapphires, sufficient to satisfy watchmakers and jewelers, who declare the artificial to be superior to the natural gems. The base of the former is alumina, and when it is submitted along with its compounds to a long and intense furnace heat, it crystallizes; the crystals will scratch quartz, and the rubies, when subsequently heated, will lose their color, re-acquiring it, however, on cooling, as is the case with the natural precious stone. Rock crystal, agate and jasper are only oxides of a metal called silicum, but it is still crystallized silica; rubies, sapphires, &c., are but oxides of the metal aluminum, or clay, but this clay is crystallized. All the difference thus resides in the arrangement of the constituent atoms. Precious stones are but crystallized pebbles. There is a strong tendency in France to prosecute investigations respecting the combinations of minerals.

By means of a recent discovery of the valuable properties of the Brazilian plant jaborandi, the most refractory constitution can be made to transpire a quart of perspiration in the space of an hour. But what is not the less remarkable, another medicament, sulphate of atropine, can prevent that transpiration. Strange results from two drugs successively administered. If when the beads of perspiration are rolling most profusely, a dose of the atropine be administered, these beads will be stopped as if by enchantment and so well that if the individual were to enter a Turkish or vapor bath the skin would remain perfectly dry. The atropine is administered in very small doses, as a pill, and with great prudence. In pulmonary consumption, for example, the importance of this drug in checking night perspiration, is incalculable.

The wine merchants of Paris appointed a committee of practical and scientific judges to examine if salicylic acid, an excellent antiseptic, could preserve wine from fermenting, &c., without altering its taste or quality. The fact is, we know very little that is certain about this acid. The report states that the acid acts differently, following the origin, strength and manner in which the wine is conserved, if in bottle or wood. In the case of the thin wines of the centre of France, it alters them profoundly, and renders them disagreeable to the taste. It has no favorable action on red wines, and the good it has been said to effect in white wines is but small. It is not within

the province of "industry" to ameliorate wines; the beneficial change must be looked for in a superior selection of vines, appropriate soil, careful cultivation and skillful processes of vinification.

The Greeks dedicated the grasshopper to Apollo, as the type of bad poetry, and the swan as the symbol of melody. Prof. Carlet, of Grenoble, has examined the "grasshopper's song:" it consists of a "drum" apparatus, beneath the second ring of the stomach, (and inside,) over which muscles internally stretch, and when contracting, form the "sticks" that beat. The professor has successfully modeled an apparatus, which "sings" very well.

F. C.

SCIENTIFIC MISCELLANY.

*ASTRONOMICAL NOTES.—MARS.

BY PROF. C. W. PRITCHETT.

In continuation of my note on Mars, of last month, it is befitting the time and subject to recur to Prof. Asaph Hall's recent investigation of the position of the south Polar spot on that planet. He has not only achieved enduring and world-wide distinction by the discovery of those unique satellites which for so many ages have eluded all the efforts of human vision, but contemporaneously, has conducted this investigation, requiring at once great skill in observing and rare mathematical ability in combining and applying observations. True, investigation so continuous and pains-taking, does not attract the attention and elicit the wonder of mankind, as does the discovery of systems hitherto unknown, yet its value to science must not be depreciated.

From the time of Sir William Herschel it has been known that this celebrated land mark on Mars was not coincident with the true pole of the planet; and yet the north polar spot of Mars has been found both by Mädler and Father Secchi to be coincident with his true north pole. Granting the spots to be vast accumulations of ice and snow, we have here an anomaly—something very unlike the phenomena of our own planet. On the earth, it is true the poles of cold do not coincide with the poles of rotation, yet the poles of cold are opposite to each other, and symmetrically situated with respect to the earth's pole. From observations made during August, September and October, Prof. H. deduced 34 equations of condition, which, combined by the method of least squares, gave three normal equations, and from these was deduced a new angular value, for the centre of the south polar spot, as measured from the true pole. It is interesting to

* Received too late for insertion under proper heading.

compare this result with the work of other celebrated astronomers. I copy them from the paper of Prof. H. in Ast. Nach., No. 2,174. The letter V denotes the angular distance of the centre of the spot from the south pole of Mars.

Herschel.....	1783, v= 8. 8°	Linseer.....	1862, v= 20.10°
Bessel.....	1830, v= 8. 6	Kaiser.....	1862, v= 4.16
Beer and Mädler,	1837, v= 12. 0	Hall.....	1877, v= 5.11
Secchi.....	1857, v= 17.42		

The anomaly above mentioned, with other reasons, has led some astronomers of late to question the long admitted theory that the spots are accumulations of snow and ice. At the meeting of the Royal Astronomical Society, of London, Nov. 9, 1877, a paper was read by Mr. Brett, tending to show that the received hypothesis of similarity in physical conditions between the earth and Mars is utterly untenable. The fundamental fact on which he reasons is the alleged absence of clouds in the envelope of the planet. He also asserted that the spot was not continuous with the surface of the planet, but lay far above it. This he concludes because no dark patch on the planet ever reaches to the limb, while the white south polar spot protruded beyond it. He suggested that the south polar spot is a permanent cloud, and the only real cloud in Mars. Prof. Hall's observations, however, made on the clearest nights and with the largest refractor now in use, seem to indicate very distinct markings or notches on the edge of the spot, and that it is really a depression in the surface of the planet. The hypothesis of a depression in the surface at once rids us of the anomaly of eccentric poles of cold, and seems more reasonable than that of one solitary and permanent cloud in the upper atmosphere of the planet.

I am gratified to add that Prof. Hall has received from the Academy of Sciences, Paris, the celebrated Lalando prize. No better evidence could possibly be afforded of the high estimate placed on his discovery of the Mars moons. It is the judgment of the successors of such men as Lalando, Laplace, Delambre and Leverrier.

I am privately informed that Prof. Hall has selected for the new satellites names, significant at once of their attendance on Mars and of their rapid rotation. The outer satellite is to be named Deimos, and the inner one Phobos. These personations of terror and fear, in the mythology of Homer and Hesiod, are always represented as attendant on Mars, (Ares in German) the god of desolation and war—sometimes they are mentioned as his sons, at other times as his charioteers, and even as his fiery steeds. In Homer, Phobos personified, means *flight*, the resultant of Deimos *terror*. So Liddell and Scott, and so Pope has it.

Iliad, Book XV, line 119:

> "With that he gives command to Fear and Flight,
> To join his rapid coursers for the fight;
> Then, grim in arms, with hasty vengeance flies—
> Arms that reflect a radiance thro' the skies."

Also, Iliad, Book IV, line 440:

"These Mars incites, and those Minerva fires
Pale Flight around and dreadful Terror reign,
And Discord, raging, bathes the purple plain."

"Flight" is surely an appropriate name for the inner satellite of Mars, which revolves around its primary more than three times in one of our days. Prof. Hall is this winter engaged in a full discussion of all the observations on the Mars moons. The results will no doubt be given to the astronomical journals in due time. The major part of his observations on these satellites were published in Ast. Nach., No. 2,161. Our observations on them at this Observatory were published in Ast. Nach., No. 2,172. From notes accompanying the observations, it may be seen that on September 7th we were able to see both satellites with the planet in the field. Usually the planet was shut out of the field; and on one occasion the inner satellite was measured, when only 7.6″ distant from the disc of Mars.

MORRISON OBSERVATORY, FEBRUARY 12, 1878.

AMERICAN EXHIBITS AT THE PARIS EXHIBITION.

The rapid approach of the time fixed for the opening of the Paris Exhibition of 1878, renders it incumbent on us to remind those of our readers who intend to take action in this connection, that they should enter at once upon the preparation of their exhibits, so as to send in applications for space as soon as the commission shall have been appointed by our government.

It is of very great importance to this country that our inventors and manufacturers should be well represented in Paris next year. The French have an idea that this is a country of inventors and mechanics, but are entirely ignorant as to the specialties in which we excel. We should show this to them through the medium now offered us at the expense of both governments. There will undoubtedly in the future be a considerable market for our productions in Europe. Among the many subjects which should be exhibited in Paris are the following:

Special processes for the treatment of ores for the extraction of the precious metals; all kinds of machinery used in mining, milling, and concentration of ores, such as hoisting and pumping engines, ventilators, rock drills, ore dressing machinery, smelting, roasting and chloridizing furnaces, hotblast arrangements, Bessemer and Siemens-Martin plant, etc.; wire ropes, rope tramways, iron bridges, in which our engineers excel; engineer's instruments, mineral samples and products, manufacturing and agricultural machinery and products.

Though the time is exceedingly short, it is sufficient, with the characteristic energy of our people, to make our exhibit creditable if suitable measures be immediately undertaken.

The Paris Exhibition is national and under the entire control of the government. Space, steam power, gas and water, are given free. Goods,

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products or inventions entering the Exhibition grounds are protected upon the simple application for a certificate, delivered gratuitously, and the said certificate is good for three months after the close of the Exhibition, and without prejudice to the patent. All goods exhibited and sold shall pay only the duty according to the tariffs of the most favored nation. This is the best opportunity that can be offered to American manufacturers to learn how they can compete with other nations in foreign markets.

Messrs. Haight Bros. & Co., of 25 Pine street, New York, offer to attend to American exhibits at the Exhibition, and, having in their partner, M. Chantal, a gentleman long connected with French-American affairs in Paris, will, we have no doubt, do so with entire satisfaction to those who intrust them with their business; they can also furnish any information which proposing exhibitors may desire.—*Engineering and Mining Journal.*

MAINTENANCE OF THE PAVEMENTS IN PARIS.

For cleaning streets, machine sweepers are employed drawn by a single horse, cleaning about 5,000 square meters an hour.

The cost of keeping in repair is quite different for the different avenues; For the Rue Lafayette it is 16.08 francs.

The asphalt roadways have a joint area of 225,120 square meters, to which should be added about 34,000 square meters for the walks through the Macadamized streets. The price of construction varies from twelve to fifteen francs per square meter.

The repairing is done by contract for 1.10 francs per square meter per year for the roadways, and 1.70 francs for the walks.

The mean cost of repairing roadways in Paris, which was 1.08 francs in 1870, has been reduced to 0.82 francs. This reduction is due especially to a change in many places from Macadam to paved roadways. The mean cost of repairing pavement never exceeds 0.60 franc, while Macadam roadways cost 1.80 francs per square meter. The latter should therefore be replaced, except where they serve as promenades and ornaments, as in the boulevards and avenues.

The following estimates are extracted from a recent report to the Municipal Council of Paris by M. Watel.

The number of vehicles which pass daily through some of the principal thoroughfares of the city have been ascertained to be as follows:

Boulevard de Sebastopol	11,602
Avenue des Champs Elysees	11,734
Rue de Rivoli	13,898
Rue Royale	16,117
Boulevard des Capucines	19,043

The paved roadways have an aggregate total area of 5,458,000 square meters; their maintenance requires the constant service of 431 men (*cantonniers*). The cost per square meter varies from 15.90 francs to 20.40 francs according to the gauge (.10 to .16 meter).

The cost of hand labor in keeping the pavements in order is 0.154 francs per square meter.

The Macadamized roadways cover an area which, although less than in 1870, is still 1,900,000 square meters. The number of *cantonniers* required for their maintenance is 965.

The steam rollers employed weigh about thirty tons each. The rolling is generally completed in a single night.—*Van Nostrand's Magazine.*

KANSAS WEATHER REPORT FOR JANUARY, 1878.

PREPARED BY PROF. F. H. SNOW, OF THE STATE UNIVERSITY.

STATION.—Lawrence, Kansas; latitude, 38°, 57′, 25″; longitude, 95°, 16′; elevation of barometer and thermometer, 875 feet above the sea level, and five feet above the ground; rain gauge on the ground: anomemeter, 105 feet above ground, on the dome of the University building, 1,200 feet above the sea level.

The month was remarkable for its high temperature and large rainfall.

Mean temperature, 33°.97, which is 8°.04 above the January average of the ten preceding years. January, 1876, however, was slightly warmer, having a mean of 34°.70. The highest temperature was 55°, on the 24th; the lowest was 7°.5 on the 6th, giving a monthly range of 47°.5. This is a very limited range, indicating unusual uniformity of temperature. The mean at 7 A. M. was 38°.30; at 2 P. M., 40°.53; at 9 P. M., 33°.56. There were 22 days during the month whose mean temperature was above freezing point. The mercury has not reached the zero point during the winter.

Rain, 3.05 inches, which is 1.85 inches above the January average. Either rain or snow fell on nine days. There were flurries of snow on the 8th and 13th, not enough for measurement. There was a brisk thunder shower on the 26th, with hail and sharp lightning. The entire depth of snow for the winter thus far has been half an inch.

Mean cloudiness, 46.77 per cent., the month being 1.49 per cent. clearer than usual. The number of clear days was 14 (entirely clear, 9; half-clear, 9; cloudy, 8 (entirely cloudy, 8). Mean cloudiness at 7 A. M., 53.22 per cent.; at 2 P. M., 47.42 per cent.; at 9 P. M., 39.68 per cent.

Wind—N. W., 43 times; S. W., 24 times; N. E, 17 times; S. E., 5 times; E., twice; N., once; W., once. The entire distance traveled by the wind was 9,996 miles, which gives a mean daily velocity of 322.45 miles, and a mean hourly velocity of 13.43 miles. The highest velocity was 40 miles an hour from 2 to 3 P. M. on the 5th.

Mean height of barometer, 29.144 inches; at 7 A. M., 29.158 in.; at 2 P. M., 29.120 in.; at 9 P. M, 29.151 in.; maximum, 29.618 in., on the 6th; minimum, 28.835 in., on the 11th.; monthly range, 0.783 in.

Relative humidity—Mean for the month, 73.4; at 7 A. M., 82.4; at 2 P. M., 57.3; at 9 P. M., 80.2. Greatest, 94.7 on the 13th; least, 37.4 on the 23d. There was no fog.

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BOOK REVIEWS.

BRYANT'S POPULAR HISTORY OF THE UNITED STATES. Vol. I. pp. 638, large octavo. Scribner, Armstrong & Co., New York: 1877.

This work has been called forth by the very evident want of a history of the United States intermediate between those prepared for schools and those which are too voluminous for general use; one which would combine an attractive style with a complete and authentic record of events. Perhaps no man in this country could have been selected who is better adapted to this work than the veteran writer and scholar, William Cullen Bryant. Having lived in and through the earlier days of our history, during the administrations of Jefferson, Adams and Jackson, and while Webster and Clay were leaders of American politics, and having published for a half century one of the leading metropolitan newspapers, he has necessarily been more or less intimately acquainted with most of the stirring events of the times, past as well as present, and is thus enabled to write with a confidence, freshness and accuracy unequalled by those historians who compile their facts from extraneous sources.

His coadjutor, Mr. Sidney Howard Gay, also an editor of long experi- is noted for his knowledge of American history, elegant style and accuracy in details.

Between the two, it is not strange that an excellent and most readable history has been produced, adapted equally to the wants of the scholar and the tastes of the masses of readers. The volume now ready, is made up of the period extending from the first discovery of the Western Hemisphere to the establishment of the several colonies along the Atlantic coast and the beginning of their colonial career.

The chapters on Pre-historic Man, the Mound Builders, the Northmen in America, and the Pre-Columbian Voyages of Discovery, are extremely interesting, as well as novel and out of the usual course in historical works on the United States.

The illustrations, numbering some 320, are first-class, from the beautifully engraved portrait of Bryant himself, to that depicting the trial of Mrs. Hutchinson in Massachusetts (1657) for preaching strange doctrines in public.

The mechanical work is fully up to the standard of the well-known publishers, and will compare favorably with that of any other house in the country. The complete work will comprise four volumes. It is sold only by subscription, and Mr. A. Hart, the agent for this portion of the West, is meeting with satisfactory encouragement.

WORDS: THEIR USE AND ABUSE, by Professor William Matthews, L. L. D. Chicago: S. C. Griggs & Co.; 1877. pp. 384. Sold by Matt Foster. $2.00.

Professor Matthews is one of those rare writers, who can in all instances combine the useful and the elegant in such proper proportions as to exactly

hit the popular fancy and taste. After publishing a half dozen volumes, all diverse in subject, yet alike in popular treatment, he remains in demand by the best readers, and his new work on Oratory and Orators will be sought for with as much avidity and read with as keen a relish as any of those that have preceded it.

The present work is devoted to the consideration of the significance, use and abuse of words under various headings, such as The Morality in Words, The Secret of Apt Words, The Fallacies in Words, The Common Improprieties of Speech, etc., etc., all of which are treated in an attractive and practical manner, well adapted to make a lasting impression upon the reader's mind.

His illustrations of the derivations of certain words and phrases are most copious and interesting—this chapter alone being well worth the price of the book. Few politicians are aware that the term "caucus," so often used by them, is derived from *Cawcawas*, a council-board among the Checahamania Indians; not all teachers know and practice upon the knowledge that "education" is derived from *educare* and not from *educere*; few christians are aware that the Bacchanalian exclamation "hip, hip, hurrah!" is made up from the first letters of the words *Hierosolyma est perdita!* being originally a war-cry adopted by the stormers of a German town, in putting the vanquished Jews to the sword; and not many Londoners will be willing to give up the story of Whittington and his cat for one which converts the *cat* into the French *achat* or *acat*, simply meaning trade or barter.

In some of these exercises the Doctor's derivations seem pretty far-fetched and the words capable of easier explanations. For instance he expends a page in tracing the expression of "apple-pie order" to its origin, and finally concludes that it is derived from *chapel* (printing office) *pie order*, which is either good order or disorder, as the case may be; when it would be quite as easy and equally plausible to attribute it to a slight misapplication and mispronunciation of the French "cap a pie." He also errs occasionally in the spelling of a word used as an illustration, as for instance, *carryvan* for *caravan*, *megalosaurius* for *megalosaurus*, but such things are very rare, and we conclude as we began, with saying that it is a most entertaining, useful and instructive work.

As is the case with all of S. C. Griggs & Co's publications, the typography, paper and binding are of the best quality.

THE PRICE CURRENT ANNUAL REVIEW; 1877. This is an exhaustive and comprehensive exhibit of the business of Kansas City for the year 1877; one which reflects equal credit upon the city and upon Messrs. Hasbrook & Simmons, who have devoted so much time and pains to its compilation.

PROCEEDINGS OF THE POUGHKEEPSIE SOCIETY OF NATURAL SCIENCES. Vol. I, Part I: 1875.

The Poughkeepsie Society of Natural Science was organized September, 1874, and this volume contains a selection from the various papers read be-

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fore it during the first year of its existence The work done makes a very creditable showing, and these papers will compare favorably with those of much older societies. Two of the contributions, one on "Insects as an Article of Food," and the other on "Fungus Eating," are very interesting, to the general reader as well as the scientist. The Proceedings are gotten up in good style, with illustrations to some of the papers. The Society is composed of excellent material, having a good corps of working members, who aim at a high standard of excellence in all that they do.

EDITORIAL NOTES.

THIS NUMBER completes the first volume of the REVIEW, and upon looking over the year's work, we are tolerably well satisfied with it. Our effort at all times has been to make it an acceptable visitor to all classes of readers, and with this in view we have been compelled to procure our articles from a large number of sources. Fortunately our contributors have used their talents upon diverse subjects, and our exchanges comprise periodicals, both English and American, devoted to almost every branch of science, so that our task has been comparatively easy, after all.

It is a matter of pride to us that so many of the distinguished scientific men of the West have deemed the REVIEW a suitable medium for placing their ideas, theories, records and discoveries before the reading public, and we have assurances that there will be no falling off in this respect in the future.

We have given our readers seven hundred and sixty-eight pages of well printed, substantial and reliable reading matter, comprising original articles by more than twenty able writers, and selected from a list of over fifty of the best scientific, medical, educational, agricultural and literary periodicals in the world, and have distributed for our advertisers twelve thousand copies of the REVIEW in more than half of the States of the Union, but principally in Missouri, Kansas and Colorado, where it has reached not less than four or five times as many readers.

The REVIEW has been warmly welcomed by the press of the country, both scientific and literary, and has been quite as well patronized, especially in Kansas City, as could possibly have been expected, considering that it is the first publication of the kind which has ever been started in the West. Another year we shall hope to improve it in several respects, still, however, only attempting to adapt it to the popular rather than to the strictly scientific taste. We shall also hope for an increased support, both at home and from a distance.

In fact, the only thing now wanting to make the REVIEW a permanent publication is more subscribers and a few more advertisements. We feel that we ought to have both; not as a gratuity, however, but because our periodical is worthy of them, and will repay both as a business investment.

THE KANSAS CITY ACADEMY OF SCIENCE met at its rooms on the evening of January 29th, and notwithstanding the disagreeable weather there was a full attendance. Before the commencement of the regular exercises, those present availed themselves of the opportunity to inspect the fine collection of stuffed birds prepared and presented by Mr. Frank Devens.

At eight o'clock Judge West called the meeting to order, and Col. Van Horn proceeded to read his paper upon "The Atmosphere and its Phenomena." As the article is printed in full in this number of the REVIEW, it is unnecessary for us to say more than that

the essayist's views are clearly stated, his statements fully supported by facts, his premises so laid down as to legitimately and logically lead to his conclusions, and that the paper was listened to with marked interest from beginning to end. None which has been presented to the Academy has elicited more discussion or called forth more or warmer complimentary comments.

At the close of Col. Van Horn's paper one by Prof. G. C. Broadhead, upon "Meteors and Meteorites," was read. It, also, is printed in full in this number of the REVIEW. It will be found a full, complete and accurate account, and one which will be extremely interesting to meteorologists and others.

PROF. KEDZIE places us under obligations by sending us copies of the original announcements by MM. Pictet and Cailletet of their success in liquefying oxygen, hydrogen and nitrogen, gases which have hitherto resisted and been supposed incapable of being reduced to solid forms.

WE are compelled to apologize for the extremely unartistic appearance of the cuts illustrating Prof. Pritchett's astronomical article. They reached us too late to have the damages repaired, and we were obliged to use them, bad as they are, or leave them out altogether.

AS WE have stated before, we can club the REVIEW with any of the Literary or Scientific Magazines of the country, so as to save to subscribers one dollar or more on the two periodicals.

SUBSCRIBERS who have not received all of the numbers of the REVIEW for the past year will be supplied with those missing *gratis* upon calling upon the editor. All others wishing back numbers will be supplied at twenty cents each.

WE have made arrangements for binding the first volume of the REVIEW in half morocco, with cloth sides, at $1.00 per volume, if ten or more volumes are sent in at one time. Persons at a distance will have to send 28 cents in addition to the above sum to cover return postage, unless they find that express charges will be less.

CLEOPATRA'S NEEDLE has at last been safely delivered at London, and the caisson containing it is now safely moored in docks furnished by a liberal mercantile firm of the city.

TO ALL new subscribers to the REVIEW for the next year we will furnish a bound copy of the first volume at the reduced price of $3.00.

NOTICES OF PUBLICATIONS RECEIVED.

WE are much gratified at being able to number among our exchanges the following valuable and popular periodicals, which have been added to our list within the past month:—

THE ATLANTIC MONTHLY, a veteran among the literary magazines of this country, being in its forty-first volume, and having maintained during all that time an unsurpassed reputation for furnishing its readers excellent as well as elegant articles, whether in prose or verse, on all the topics of current literature, has added to its attractions by consolidating with itself the well-known and popular *Galaxy*. All of the old contributors to the *Atlantic*, such as Longfellow, Holmes, Howells, Aldrich, "Mark Twain," etc., will continue to enrich its pages, while most of those who gave to the *Galaxy* its freshness and sparkle will be retained and will lend their brilliancy to the survivor. Published by Houghton, Osgood & Co., Boston, Mass. $4.00 per annum. Single numbers, 35 cents.

THE INTERNATIONAL REVIEW. Vol. V., No. 1; January and February, 1878. Published by A. S. Barnes & Co., New York. $5.00 per annum; single numbers, $1.00. This periodical, though comparatively a new one, has rapidly assumed strength and position, and now stands among the foremost of the standard *Reviews* of the United States. The present number contains articles by such well known and able writers as Whittier, David A. Wells, Ernst Curtius, Edward A. Freeman, Major Ben. Perley Poore, Prof. W. C. Sumner, Alex. H. Stephens, and others, both in this country and Europe, equally noted as writers and thinkers.

The tone of the *International* is fresh and wholesome, and its choice of articles is characterized by a discriminating liberality and cosmopolitanism, making it strictly what it purports to be, a review of the international sentiment of the age in literature, science, politics and religion.

HARPER'S NEW MONTHLY MAGAZINE, for March, 1878. Harper & Brothers, New York. $4.00 per annum: single numbers, 35 cents. This, the most popular of all the illustrated monthlies, although in its fifty-sixth volume, still adhers to its original title of Harper's *New* Monthly, which is in truth most appropriate, for each number is a "new thing" and more attractive, if possible, than the one before it. Being one of the first of American magazines to adopt the illustrated style, it has kept it up ever since with increasing excellence, until now the engravings, both in the Monthly and the Weekly, are works of art worthy of preservation for their artistic merit aside from the value of the letter-press which they illustrate.

It is quite unnecessary to go into any extended notice of this periodical, as it is known in every corner of the United States, and is found in the cabin of the Colorado miner and of the Kansas ranch-man as universally as in the parlors of Eastern capitalists and *literati;* but to those who have not decided to renew their subscriptions for this year, we will say that its scientific articles are as ably written and illustrated, its historical, geographical and literary articles as attractive, its editorial notes as fresh and sparkling, its scientific record as full and complete and its Drawer as irresistably "funny" as ever, and that no magazine in the country excels it for family reading adapted to all classes, old and young, wise and simple.

THE LITERARY WORLD. Published monthly by E. H. Hames & Co., Boston. $1 50 per annum; 10 cents for single numbers. Vol. 8, No. 8. This periodical, like the *Library Table*, of New York, is devoted to descriptive notices and critical reviews of new publications, and a general review of literary matters of all kinds. It is admirably edited, and is regarded by all librarians as a most useful aid to them in purchasing books.

THE YOUNG SCIENTIST. Vol. 1, No. 1. Published monthly by the Industrial Publication Company, N. Y. 50c per annum; 6c for single numbers. This is a successor to the *Technologist*, and judging from the first number, which is made up of articles upon useful and popular subjects, it will be a valuable work for students and young scientists, for whom it is especially intended, as its title indicates.

THE AMERICAN BOOKSELLER. Vol. 5, No. 3. Published by the American News Company, N. Y. $1.00 per annum; 5c per single copy. This is a semi-monthly journal, devoted to the interests of the book, stationery, news and music trades, and contains copious criticisms and reviews of current literature, lists of new books, and a very complete monthly index of the principal articles in all the periodicals of the country. It is a most useful publication for all readers and students.

BISHOP MARVIN'S "To the East by Way of the West," Marvin's Lectures on the "Errors of the Papacy," and Rev. Eugene R. Hendrix's "Around the World," with introduction by Bishop Marvin; price of each book, $2.00. ☞ AGENTS WANTED everywhere. Send amount named to Logan D. Dameron, agent of the Advocate Publishing House, St. Louis, and get sample copies of either, or all three, with terms to agents. The books are selling rapidly. Some agents have sold 50 copies in a single day.

A VERY RARE and interesting fish, somewhat resembling the *Lepidosiren annectens*, was caught in the Kansas River recently. Unfortunately it was allowed to spoil, and was thrown away before its peculiarities were called to the attention of any one interested in such matters.

THE LEAVENWORTH TIMES advocates the selection of Fort Leavenworth reservation as the site for the new National Observatory. We know of no better location in the country, and hope that the choice may fall upon that beautiful and most eligible spot.